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Canotia is named for *Canotia holacantha* Torr. (Celastraceae), a spiny shrub or small tree nearly endemic to Arizona.

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FABACEAE LEGUME FAMILY

PART ONE: ERRAZURIA PHILLIPS, MARINA LIEBM., PARRYELLA TORR. & A. GRAY, AND PSOROTHAMNUS RYDB.

Suzanne Rhodes, June Beasley, and Tina Ayers

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Trees, shrubs, herbs, or vines, often with nitrogen-fixing bacteria in root nodules. LEAVES alternate, usually compound (pinnate, bipinnate, palmate) sometimes simple; stipules present, sometimes developing into spines. INFLORESCENCE a terminal raceme, corymb, spike, or head. FLOWERS usually bisexual, actinomorphic to papilionoid, hypogenous or perigynous; sepals 5, free or fused into a tube that is regular or somewhat bilabiate; petals mostly 5, rarely reduced or absent, free or fused into a tube, or the 2 lower ones often fused and the three upper ones distinct; stamens 5–10; ovary superior, composed of a single carpel with a terminal style and stigma; ovules 1-many, placentation marginal. FRUIT usually dry and opening along both sutures (a typical legume), sometimes indehiscent, sometimes breaking into 1-seeded segments (a loment); seed with hard, often impervious testa, often long-lived; embryo typically large, with 2 conspicuous cotyledons. Ca. 700 genera and 18,000 spp. of worldwide distribution. Some authors treat the three subfamilies, Caesalpinoideae, Mimosoideae, and Papilionoideae, as distinct families.

Economically, legumes are one of the most important plant families, contributing food and forage throughout the world. They are well represented in Arizona, especially below the Mogollon Rim. On Rupert Barneby's last trip through the American West, he suggested to June Beasley that she describe this group of *Dalea* segregates (*Errazurizia*, *Marina*, *Parryella*, *Psorothamnus*) for the VPA project. These genera along with *Amorpha*, *Dalea*, and *Eysenhardtia* all belong to the tribe Amorpheae, which in turn belongs to the subfamily Papilionoideae with pea-like flowers. We here provide a key to the AZ genera of the Amorpheae and a taxonomic treatment of the *Dalea* segregates. The Amorpheae are members of the Papilionoideae, which generally have bilaterally symmetric flowers with the uppermost petal (the banner) external in the bud and the two lowermost petals forming a keel. The Amorpheae can be distinguished from other tribes of Fabaceae by a combination of characters, namely: the presence of oil glands in the epidermis of the stems, leaves, calyx and sometimes the petals, these parts aromatic when bruised; hairs simple, basifixed; inflorescence determinate; ovules usually 1–2; fruit usually 1-seeded, indehiscent, falling with the calyx.

Key to Genera of Amorpheae

1. Corolla none or reduced to the banner petal 2
 2. Petal 1, conspicuous, dark violet; filaments united at base; leaflets mostly 1–2 cm long *Amorpha*
 - 2' Petals none, or 1 inconspicuous pale yellow banner petal; filaments distinct; leaflets mostly 0.5–1.0 cm long 3
 3. Herbage with appressed to ascending long, straight, soft hairs; leaflets obovate to orbicular, obtuse or shallowly notched, 3–5 mm wide *Errazurizia*
 - 3' Herbage glabrate to sparsely strigose; leaflets narrowly linear to narrowly obovate, acute, concavely folded, not more than 2 mm wide *Parryella*
- 1' Corolla with 5 petals 4
 4. Shrubs with white corollas; flowers in elongate, spike-like racemes; pods thin, flat, long exserted from calyx *Eysenhardtia*
 - 4' Herbs or shrubs, if shrubs the corolla not white; flowers in loose or dense heads or spikes, or racemes; pods turgid, included in calyx, or long exserted in a few shrubby species 5
 5. Petals inserted on the calyx at base of stamen tube; trees and shrubs *Psorothamnus*
 - 5' Petals (the paired ones) inserted on the stamen tube; herbs, subshrubs, or small shrubs 6
 6. Ovule solitary; flowers short-pedicellate; hairs of calyx usually grayish white .. *Marina*
 - 6' Ovules 2, but only one maturing into a seed; flowers sessile; hairs of calyx usually brownish yellow *Dalea*

Errazurizia Philippi Round-leaf Dunebroom

Low, stiff, gnarled, aromatic shrubs. STEMS much-branched, unarmed, light gray-green, becoming gnarled and gray in age, with prickle-shaped glands and appressed to ascending long, straight, soft hairs. LEAVES alternate, deciduous, odd-pinnate with (10–)14–20(–30) pairs of obovate to orbicular, obtuse or shallowly notched, flat leaflets, glandular punctate especially beneath, densely pubescent; stipules small, deciduous. INFLORESCENCE a terminal, short, few-flowered raceme; bracts early deciduous. FLOWERS apetalous or very rarely with a small, inconspicuous pale yellow banner; calyx turbinate or campanulate, with tube 10-ribbed, with broad, short teeth, bearing 2–5 orange glands in the rib intervals, densely silky-hairy along margins and within; stamens 10, basally united; ovary 2-ovuled. FRUIT a 1-seeded indehiscent pod, exserted from the calyx, ellipsoid to obovoid, gray canescent, conspicuously red gland-dotted, beaked by a persistent style. —4 spp.; w US, Baja C. and coastal Son., Mex., Chile (for Errazuriz family of Chile). Barneby, Rupert C. 1977. Mem. New York Bot. Gard. 27:13–21, 594, 597.

Errazurizia rotundata (Wooten) Barneby (rounded, in reference to the leaflets) (Figs. 3A, 5A–B). —Low, twiggy, sometimes sprawling subshrub up to 30–40 cm high with repeated branching upwardly. LEAVES 3–14 cm long; leaflets 1–7 mm long, 1–4 mm wide. CALYX 4.5–6.0 mm long; filaments light green,

conspicuously exserted from the calyx and nearly twice as long; anthers bright yellow. FRUIT 9.5–12.0 mm long, up to 5 mm wide. [*Parryella rotundata* Wooten]. —On red or white sandstone pavement and ledges, in sandy crevices among rocks, or in loose, drifted sand: Coconino, Navajo cos. (Fig. 1A); 1350–1500 m (4500–5100 ft); Apr-early May; known only from a few localities in n AZ, all within the drainage of the Little Colorado River.

Marina Liebm. False Prairie-Clover

Perennial herbs or shrubs, aromatic when bruised. STEMS much-branched, unarmed, sparsely pubescent with straight or curly reddish hairs; glands sparse or absent. LEAVES alternate, deciduous, petiolate, odd-pinnate with 3–10 pairs of obovate to oblong-obovate or shallowly notched flat leaflets, glabrous to pubescent; stipules small, deciduous. INFLORESCENCE a terminal raceme or open panicle; bracts early deciduous. FLOWERS with showy bi-colored petals; calyx turbinate to campanulate, the tube 10-ribbed, bearing 2–5 yellow, orange, or red-brown glands between the ribs; calyx lobes shorter than the tube; petal wings and keel elevated on a column continuous with the staminal tube; stamens generally 10, the filaments fused; ovary 1-ovuled. FRUIT a 1-seeded pod, ovoid, exserted from the calyx, conspicuously red gland-dotted, beaked by a persistent style. —38 spp.; sw U.S. (CA, NM, NV), Mex., C. Amer. (In honor of Marina or Melinche, interpreter for Cortés during the conquest of Mexico). Barneby, Rupert C. 1977. Mem. New York Bot. Gard. 27:55–135.

1. Plants decumbent or nearly so; stems entirely herbaceous; inflorescence a dense, pilose raceme; stems and leaflets hairy, not glandular *M. calycosa*
- 1' Plants upright; stems ascending, often shrubby or slightly woody at the base; inflorescence a loose raceme or panicle; stems and leaflets glabrous or sparsely hairy, glandular 2
2. Plants herbaceous when young, becoming suffrutescent in age, the stems green; inflorescence a loose, many-flowered raceme; common throughout the Arizona Sonoran desert *M. parryi*
- 2' Plants shrubby, the stems reddish; inflorescence a repeatedly and finely branched panicle; in AZ only in extreme s Santa Cruz Co. *M. diffusa*

Marina calycosa (A. Gray) Barneby (remarkable calyx). San Pedro False Prairie-clover (Fig. 4A). —Prostrate perennial herbs with glandless or nearly glandless foliage and racemes. STEMS gray-green, branched from the middle, sparsely canescent, to 30 cm long. LEAVES 1–3 cm long, shortly petiolate; leaflets obovate to oblong-obovate, 2–3 mm long, 1–2 mm wide, white pubescent. INFLORESCENCE a dense raceme 1.5–6.5 cm long. FLOWERS 7–10 mm long; calyx lobes narrowly triangular, 2.0–2.5 mm long, acute, longer than the tube, ribbed, with prominent veins, pilose; petals purple and white. FRUIT an obliquely-obovoid pod, 3.0–3.5 mm long with two rows of glands on each side. [*Dalea calycosa* A. Gray]. —Dry, open slopes and grasslands: Cochise, Graham, Pima,

Pinal, Santa Cruz cos. (Fig. 1B); 1150–1500 m (4000–5000 feet); Apr–Sep; se AZ, NM; Son. Mex.

Marina diffusa (Moric.) Barneby (diffusely branched in reference to the panicle). Spreading False Prairie-clover (Fig. 4B). —Glabrous subshrubs or suffrutescent herbs, 1.0–2.5 m tall. STEMS purple-red, repeatedly branching into slender wand-like capillary branchlets, sparsely glandular, with few fine, long hairs. LEAVES 0.5–2.5 cm long, short-petiolate; leaflets oblong-obovate, 3–5 mm long, 1–2 mm wide, gland dotted especially around the margins, glabrous. INFLORESCENCE an open finely branched panicle, the branches 2–6 cm long. FLOWERS 4–6 mm long; calyx lobes ovate, ca. 0.8 mm long, obtuse, shorter than the tube, unribbed and without prominent veins, glabrous; petals dark rose-purple and whitish. FRUIT a plumply obovoid pod, 2.7–2.9 mm long, glandular distally. [*Dalea diffusa* Moric.]. —Brushy hillsides: Santa Cruz Co. (Fig. 1C); 1350–1500 m (4500–5000 ft); Sep–Oct. Mex., Guatemala.

The Mexican name for this plant is Escoba Colorada (Red Broom) in reference to the reddish stems. The species is recognized by Barneby (1977) to have two varieties. The only AZ collection (*Hodgson et al.* 4771, ASU, DES) appears to be *M. diffusa* var. *diffusa*. The leaves are early deciduous and during the dry season individuals look like a clump of red-purple branches terminating in masses of slender panicles.

Marina parryi (Torr. & A. Gray) Barneby (for C. C. Parry). Parry's False Prairie-clover (Fig. 5C). —Erect, suffrutescent perennial, 1.5–4.0 m tall. STEMS green, brittle, much-branched from the base, dotted with dark reddish glands. LEAVES 1–4 cm long, long-petiolate; petioles 5–8 mm; leaflets obovate 4–6 mm long, 2–4 mm wide, gland-dotted abaxially, sparsely canescent on both sides. INFLORESCENCE a loose raceme, 2–10 cm long. FLOWERS 5–8 mm long; calyx lobes triangular, ca. 0.8 mm long, acute, shorter than the tube, with canescent veins, without prominent ribs; petals bright blue-purple and white. FRUIT an obliquely obovoid and compressed pod, 1.8–2.4 mm long with two rows of glands on each side. [*Dalea parryi* Torr. & A. Gray]. —Common on low deserts on granitic or volcanic soils: Cochise, Gila, La Paz, Maricopa, Mohave, Pima, Pinal, Yavapai, Yuma cos. (Fig. 1C); 0–1150 m (0–3700 ft); Mar–Jun (all year); s CA; Baja C., Son. in Mex.

Parryella Torr. & A. Gray Dunebroom

Slender, erect, pliant shrubs with a citrus aroma. STEMS broom-like, unarmed, reddish or purplish brown, becoming whitish gray in age, with raised prickle-shaped glands, glabrate to sparsely strigose. LEAVES alternate, deciduous, odd-pinnate, with 11–43 pairs of leaflets, these narrowly linear to narrowly obovate, acute, concavely folded, stipellate, glandular-punctate, glabrate to sparsely strigose; stipules minute, deciduous. INFLORESCENCE a terminal, many-flowered, spike-like raceme, bracts inconspicuous. FLOWERS yellowish, apetalous; calyx turbinate

or campanulate, the tube obscurely ribbed near base and bearing sparse orange-brown glands, with 5 broad, short teeth, these with fine short hairs on the margins; stamens 10, with filaments yellowish, distinct or nearly so, unequal, the longest exerted 2.0–3.5 mm from the calyx at anthesis; anthers yellowish; ovary 2-ovuled. FRUIT a one seeded, indehiscent pod, exerted from the calyx, obliquely oblong-obovoid, glabrous, conspicuously reddish-brown gland-dotted, beaked by a persistent style. Monotypic genus of the Colorado Plateau and upper Rio Grande Valley. (for C. C. Parry). Barneby, Rupert C. 1989. *Parryella* pp. 28–29 in Intermountain Flora, Vol. 3, Part B. Bronx, NY; New York Bot. Gard.

Parryella filifolia Torr. & A. Gray ex A. Gray (thread-like leaves) (Figs. 5D–E). —Shrubs 0.5–1.5 m tall. LEAVES (3–)5–17 cm long; leaflets 2–16 (–20) mm long, 0.3–1.5 mm wide. CALYX 2.5–3.5 mm long. FRUIT 6(–6.5) mm long, 2.5(–3) mm wide, slightly laterally compressed. —Shrubs of dry places, often forming large clumps in sandy clay bluffs, on gravelly or rocky ledges, in grassland, or deep sand, commonly in hummocky dunes: Apache, Coconino, Navajo cos. (Fig. 1D); 1500–1950 m (4900–6450 ft); May–Sep; NM, UT.

A variant with broader leaflets (16–20 mm wide) is found within the range of the typical form in northeastern AZ. According to Barneby (1989), it occurs sporadically and appears to be taxonomically insignificant. The Hopi reportedly use the twigs of *Parryella* to construct baskets and brooms, the seeds to alleviate toothache, and the leaves as an insecticide. Because *Parryella* is effective in the catchment of moving sand, it is of potential value in controlling erosion in sandy areas.

***Psorothamnus* Rydb. Indigobush**

Subshrubs, shrubs, rarely tree-like (in *P. spinosus*). STEMS intricately branched, generally with thorns, glabrous to pubescent, dotted with prominent or inconspicuous, domed or prickle-shaped glands. LEAVES alternate, deciduous, petiolate, simple or odd-pinnate with 2–6(–8) pairs of linear to oblong leaflets, these flat or folded, glabrous to pubescent; pedicels generally with bractlets; stipules small, deciduous. INFLORESCENCE a congested or open raceme; bracts inconspicuous. FLOWERS racemose or spicate, the pedicels bibracteolate; calyx tube campanulate, 10-ribbed, bearing 1–5 yellow, orange, or red glands in the rib intervals; petals showy, purple, violet, or blue, inserted on the hypanthium rim; stamens 10, united more than half their length; ovary 2-ovuled. FRUIT a 1–2 seeded pod, ellipsoid to obovoid, conspicuously red gland-dotted, beaked with a persistent style. —9 spp.; Sonoran, Chihuahuan, and Mohave deserts, in US from CA to TX (Greek for scurfy shrub). Barneby, Rupert C. 1977. Mem. New York Bot. Gard. 27:21–54, 598–607.

Psorothamnus polydenius should be looked for in the northwestern corner of the Arizona Strip. It can be differentiated from *P. fremontii* by smaller leaflets (< 4 mm long), smaller fruits (2.0–2.5 mm long), and a dense spike-like raceme.

1. Leaves simple (rarely 3-foliate) or absent 2
 2. Broom-like subshrub, to 1 m tall *P. scoparius*
 - 2' Divaricately branched shrubs or trees, 1–7 meters in height 3
 3. Leafy irregularly branched shrubs, sparsely thorny *P. schottii*
 - 3' Generally leafless trees, densely thorny *P. spinosus*
- 1' Leaves pinnately compound 4
 4. Subshrub less than 1 m tall; fruits 2.0–4.5 mm long 5
 5. Stems with inconspicuous glands; leaflets 5–9, the terminal one 2–3× longer than the laterals; inflorescence a dense, spheric raceme *P. emoryi*
 - 5' Stems with conspicuous glands; leaflets 7–1(–19), the terminal one similar in size to the laterals; inflorescence a loose, open raceme *P. thompsonae*
 - 4' Glabrous to pubescent shrubs more than 1 m tall; fruit 7–10 mm long 6
 6. Calyx teeth 3.6–5.2 mm long, longer than the tube; fruits glabrous or finely hairy, sparsely covered with rounded or elliptic glands ... *P. arborescens* var. *pubescens*
 - 6' Calyx teeth 1.8–3.2 mm long, generally shorter than tube; fruits glabrous, densely covered with elongate glands in rows *P. fremontii*

Psorothamnus arborescens (Torr. & A. Gray) Barneby (tree-like). Mojave Indigobush. —Shrubs, glabrous to pubescent, to 0.3–1.0 m tall. LEAVES pinnately compound, 1.8–6.0 cm long; glands inconspicuous. FLOWERS in a lax, open raceme, 3.0–7.5 cm long; calyx with prominent veins, the teeth 3.7–4.5 mm long, acuminate, longer than the tube. FRUIT 7–10 mm long, glabrous or finely hairy, sparsely covered with rounded or elliptic glands. —4 vars. found in western North America, AZ, CA, NV, UT.

Var. **pubescens** (Parish) Barneby (hairy) (Fig. 5F). —Leaflets 7–13, linear to narrowly oblanceolate, 0.8–1.2 mm long, 0.5–1.5 mm wide, the terminal one equal to the laterals. [*Dalea amoena* S. Wats, *D. amoena* S. Wats. var. *pubescens* (Parish) Peebles, *D. fremontii* Torr. ex A. Gray var. *pubescens* (Parish) L. Benson]. —On rocky knolls and talus at base of sandstone cliffs: Marble Canyon area, endemic to Coconino Co. (Fig. 2A); 1050–1470 m (3450–4850 ft); late Apr–Jun.

Psorothamnus emoryi (A. Gray) Rydberg. (for W. H. Emory). Dyebush. —Subshrub 0.3–1.0 m tall, tomentose; glands inconspicuous on stems. LEAVES pinnately compound; leaflets 5–9, oblong-oblanceolate to elliptic, 4–16 mm long, 1–3 mm wide, the terminal one 2–3× longer than the laterals. FLOWERS in a dense, spheric raceme, 0.7–2 cm long; calyx densely pilose, with teeth 1.8–3.8 mm long, about the same length as the tube. FRUITS 2.3–2.8 mm long, finely hairy and glandular at apex. [*Dalea emoryi* A. Gray; *Parosela emoryi* (A. Gray) A. Heller]. —2 vars., w U.S.; Mex.

Var. **emoryi** —Calyx teeth 3.0–6.7 mm long, about as long as the tube. Fig. 5G. —deep sand, desert flats and dunes: Yuma Co. (Fig. 2B); 50–350 m; (150–1150 ft); Apr–Jun (fall). CA; Baja C., Son., Mex.

Psorothamnus fremontii (Torr. ex A. Gray) Barneby (for J. C. Fremont). Fremont's Dalea (Fig. 5H). —Shrubs, glabrous to appressed pubescent, to 1.5 m tall; glands inconspicuous. LEAVES pinnately compound; leaflets 3–5, linear to

oblong, 3–25 mm long, 1–2 mm wide, strigose. FLOWERS in a lax, open raceme; calyx teeth 1.8–3.2 mm long, generally shorter than tube. FRUIT 7–10 mm long, glabrous, densely covered with elongate glands in rows. [*Dalea fremontii* A. Gray]. —Sandy or rocky soils derived from granite and sandstone of washes, banks, and debris fans: w Coconino, Mohave, w Yavapai cos. (Fig. 2A); 350–1000 m (1200–3200 ft); (Mar) Apr–May; CA, NV, UT.

Two varieties have been recognized (Barneby 1977) and both were noted to occur in Arizona. *Psorothamnus fremontii* var. *fremontii* was separated from *P. fremontii* var. *attenuatus* Barneby based upon leaflet shape (narrowly obovate to linear-elliptic in var. *fremontii* vs. narrowly linear in var. *attenuatus*) and leaflet size (3–15 mm long \times 1.5–4.0 mm wide in var. *fremontii* vs. 5–25 mm long \times 1.0–1.2 mm wide in var. *attenuatus*). While the varieties as described by Barneby (1977) have overlapping ranges, var. *fremontii* generally occurs on sedimentary formations of limestone, and sandstone, and var. *attenuatus* occurs on volcanic and granitic bedrock. Two Arizona specimens (*A. Phillips s.n.*, MNA and *C. Schaack 1464*, ASC) have narrowly linear leaflets but the leaflets are short, suggesting that they are diminutive leaves. Further collecting in Arizona is needed before these varieties can be recognized.

***Psorothamnus schottii* (Torr.) Barneby** (for A. C. Schott). Schott's Indigobush. —Shrubs, divaricately branched, less than 2 m tall; branches sparsely canescent; glands inconspicuous. LEAVES persistent, simple (rarely 3-foliate), linear, 2.5–6.0 mm long, 1.1–2.0 mm wide, canescent above, glabrous below, gland-dotted. FLOWERS in a lax, open raceme, 1–9 cm long; calyx teeth 0.5–0.8 mm long, much shorter than tube. FRUIT 7–10 mm long, glabrous, puberulent and densely covered with discrete glands at apex. [*Dalea schottii* Torr., *D. schottii* var. *puberula* (Parish) Munz]. —Gravelly benches and washes: Yuma Co. (Fig. 2C); 45–90 m (150–300 ft); Nov–May. Colorado Desert in CA; Baja C., Mex.

Psorothamnus schottii is broadly sympatric with *P. emoryi* but they generally inhabit very different habitats. They can easily be distinguished by coloration (*P. emoryi* is hoary white and *P. schottii* is green) and leaves (pinnately compound in *P. emoryi* vs. simple or rarely 3-foliate in *P. schottii*).

***Psorothamnus scoparius* (A. Gray) Rydberg** (broom-like). Broom Dalea (Figs. 3B, 5I). —Broom-like subshrubs up to 1 m tall; stems yellow-green, canescent, prominently dotted with pale yellow glands. LEAVES simple (rarely 3-foliate), linear, 70–110 mm long, 0.8–1.2 mm wide; glands in two rows along the margin. FLOWERS in a short, dense raceme; calyx teeth 0.3–1.8 mm long, much shorter than tube. FRUIT ca. 4 mm long, pilose, with glands near apex. [*Dalea scoparia* A. Gray]. —Sandy dunes and washes: Cochise, Coconino, Navajo cos. (Fig. 2C); 1100–1550 m (3600–5000 ft); Jul–Sep; NM, TX.

***Psorothamnus spinosus* (A. Gray) Rydberg** (spiny in reference to thorny branches). Smoketree (Figs. 5J–K). —Generally leafless trees, divaricately branched, densely thorny, to 7 meters tall; glands prominent. LEAVES early deciduous, simple, oblong to obovate, 3–22 mm long, 2–5 mm wide. FLOWERS in

a lax, open raceme; calyx teeth 0.8–1.5 mm long, shorter than the tube. FRUIT 4.2–5.3 mm long, glabrous except for marginal hairs at apex; with prominent glands. [*Dalea spinosus* A. Gray, *Parosela spinosa* (A. Gray) A. Heller]. —Sandy washes and roadsides where moisture collects: La Paz, Maricopa, Mohave, Pima, Yavapai, and Yuma, cos. (Fig. 2D); 60–750 m (200–2400 ft); mainly Jun; CA, NV; Baja C., Son., Mex.

Psorothamnus thompsonae (Vail) Welsh & Atwood (for E. P. Thompson). —Subshrub, less than 1 m tall, glabrous to puberulent; glands orange-brown, prominent. LEAVES pinnately compound; leaflets 7–17(–19), the terminal one similar in size to the laterals. FLOWERS in a loose, open raceme; calyx teeth 1.5–2.0 mm long, about the same as the tube, densely hairy. FRUIT 4.0–4.5 mm long, strigose with prominent glands. —2 vars. found in sw U.S., AZ, UT.

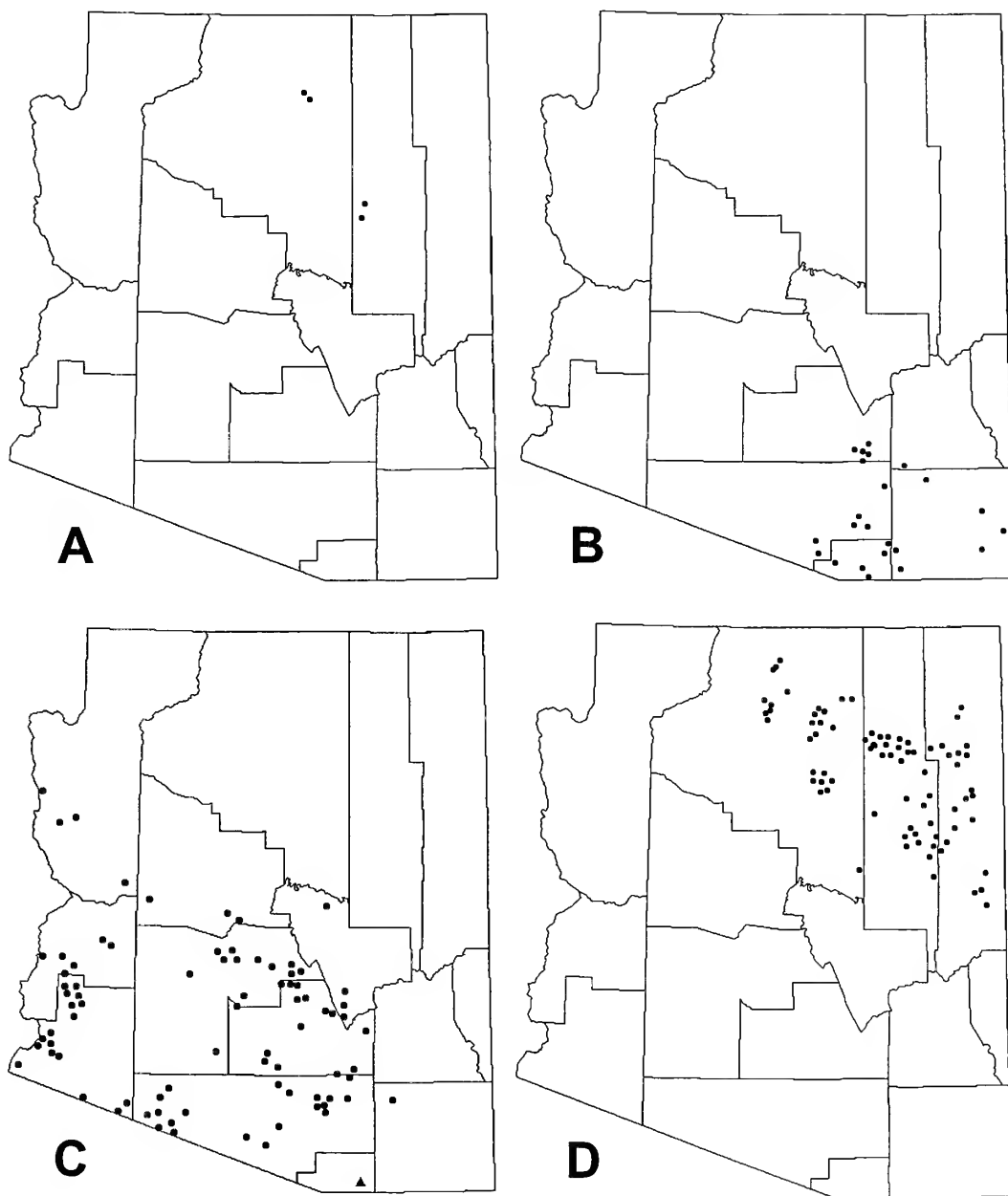
Var. ***whitingii*** (Kearney & Peebles) Barneby (for A. F. Whiting) (Fig. 5L). —Leaflets linear to oblong, 3–7 mm long, ca. 1 mm wide. [*Dalea whitingii* Kearney & Peebles]. —Low hills in deep sand and sandy washes: Coconino Co. (Fig. 2D); 1100–1850 m (4200–6000 ft); May–Aug; se UT.

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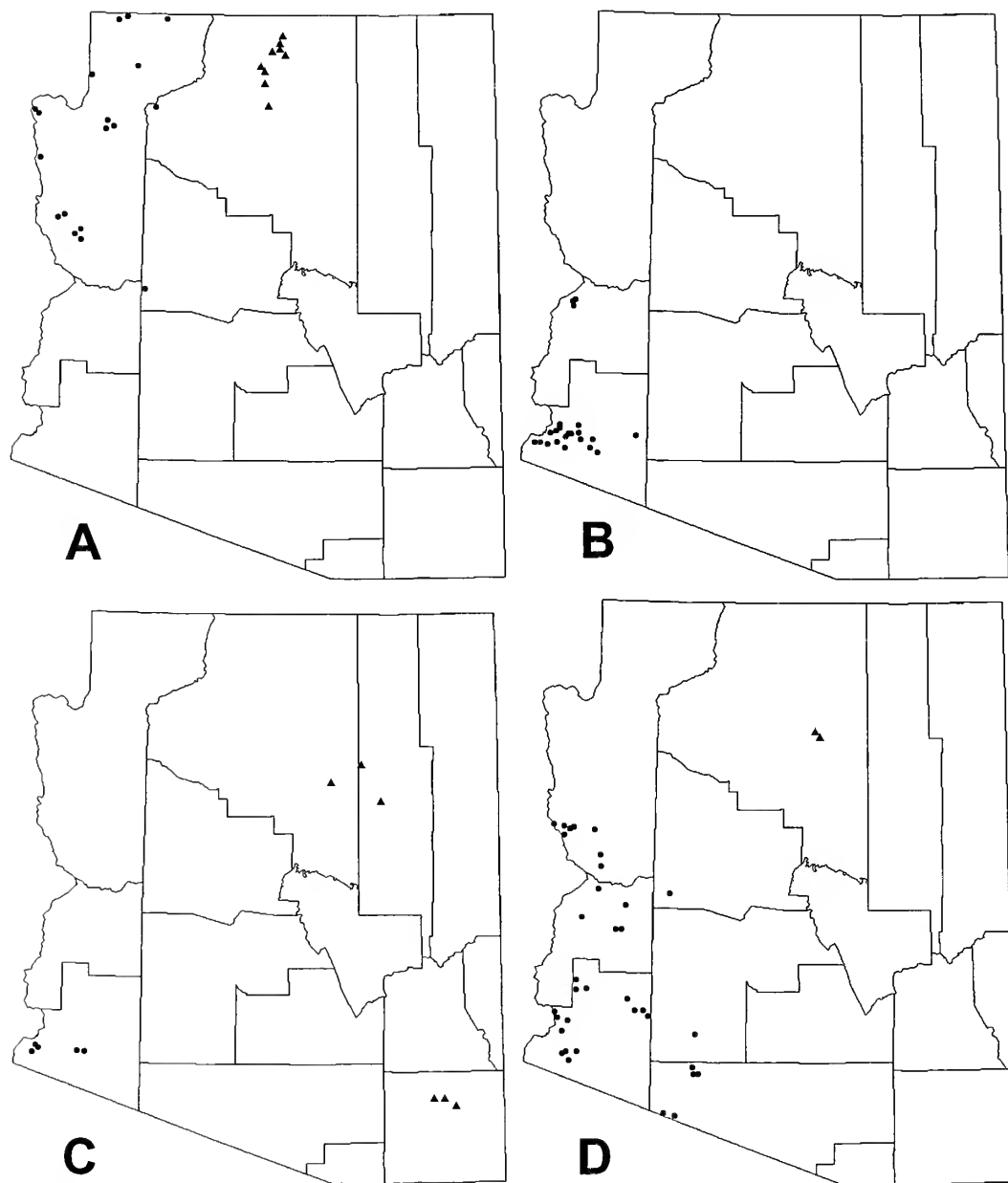
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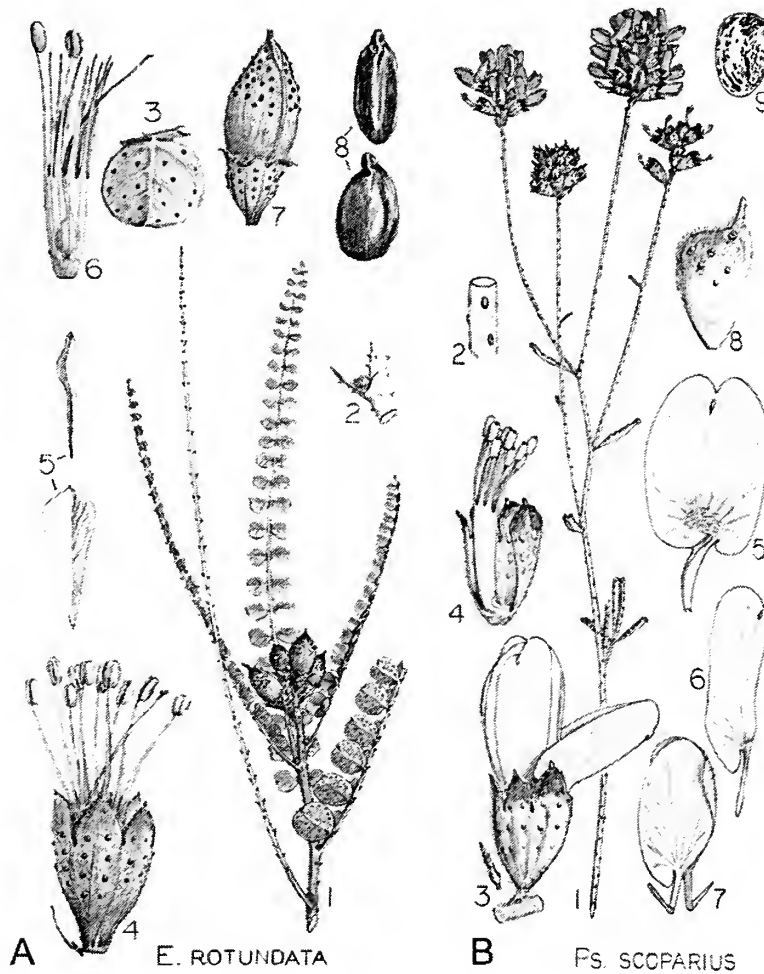
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Fabaceae Figure 1. Distributions of: (A) *Errazurizia rotundata*; (B) *Marina calycosa*; (C) *Marina diffusa* (▲) and *Marina parryi* (●); (D) *Parryella filifolia*.



Fabaceae Figure 2. Distributions of *Psoralea*: (A) *P. arborescens* var. *pubescens* (▲) and *P. fremontii* (●); (B) *P. emoryi*; (C) *P. schottii* (●) and *P. scoparius* (▲); (D) *P. spinosus* (●) and *P. thompsonii* var. *whitingii* (▲).



Fabaceae Figure 3. (A) *Errazurizia rotundata*: 1) fruiting branchlet; 2) stipules; 3) leaflet, dorsal view; 4) flower + bract; 5) banner, half-profile and ventral views; 6) androecium; 7) pod; 8) seed, ventral and lateral views; (B) *Psorothamnus scoparius*: 1) flowering branchlet; 2) piece of stem; 3) flower + bract; 4) calyx, opened to show androecium; 5) banner, ventral view; 6) wing; 7) keel; 8) pod; 9) seed. (Reproduced with permission of the publisher from: R. C. Barneby, *Dalea Imagines*. Memoirs of The New York Botanical Garden, v. 27. © 1977, The New York Botanical Garden Press, Bronx).



Fabaceae Figure 4. (A) *Marina calycosa*: 1) fruiting stem; 2) stipules; 3) leaflet; 4) bract, lateral view; 5) flower; 6) part of calyx, from within; 7) banner, ventral and profile views; 8) wing; 9) keel; 10) androecium; 11) pod; (B) *Marina diffusa*: 1) branchlet; 2) main cauline leaf; 3) leaflet, dorsal view; 4) leaf from pannicle; 5) flower, profile and dorsal views; 6) banner, ventral and profile views; 7) wing; 8) keel; 9) pod; 10) androecium. (Reproduced with permission of the publisher from: R. C. Barneby, *Dalea Imagines*. Memoirs of The New York Botanical Garden, v. 27. © 1977, The New York Botanical Garden Press, Bronx).



Fabaceae Figure 5. *Errazurizia rotundata*: (A) habit; (B) flowers; *Marina parryi*: (C) flowers; *Parryella filifolia*: (D) habit; (E) flowers and fruit; *Psorothamnus arborescens*: (F) flowers; *Psorothamnus emoryi*: (G) flowers; *Psorothamnus fremontii*: (H) flowers; *Psorothamnus scoparius*: (I) flowers; *Psorothamnus spinosus*: (J) branch tips; (K) flowers; *Psorothamnus thompsonae* var. *whitingi*: (L) flowers. (Photos A–B, L by Daniela Roth; C, F–H, J by Max Licher; D–E, I, K by Suzanne Rhodes).

THE VASCULAR FLORA OF THE HUMMINGBIRD SPRINGS WILDERNESS, MARICOPA COUNTY, ARIZONA

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ABSTRACT

The goal of this study was to inventory the vascular plants of the Hummingbird Springs Wilderness (HSW), an area covering 31,000 acres of the Sonoran Desert and located about 60 miles west of Phoenix, Arizona. In order to obtain an accurate biodiversity assessment, plants were collected in the field from January 2006 to December 2007, in a variety of vegetation zones (defined by different parameters such as elevation, aspect, or soil) in all seasons. In addition, samples of the seed bank were collected from several locations, and grown in conditions similar to a wet year in the field. A total of 270 species were collected belonging to 64 families, including 199 genera. Five families accounted for 46% of the collection: Asteraceae (38 genera, 49 species), Poaceae (20 genera and 31 species), Fabaceae (13 genera and 19 species), Boraginaceae (six genera and 13 species) and Euphorbiaceae (five genera and 12 species). Thirty-six species were collected from the greenhouse, including six species that were not collected in the field but are now presumed to grow in HSW. The flora of the Hummingbird Springs Wilderness provides a plant community snapshot that can be used in the future by a variety of researchers and government agencies.

INTRODUCTION

At a time when biodiversity is threatened by habitat loss, invasive species, and human impacts, lands designated as wilderness are important as a refugia for species, and may be examples of less disturbed ecosystems. With the passing of the 1990 Arizona Desert Wilderness Act, over two million acres of desert terrain were set aside throughout the state, increasing the total acreage of protected land to 4.8 million acres (Warren 2002). The passage of the act created nineteen areas managed by the Bureau of Land Management (BLM), including Hummingbird Springs Wilderness (HSW).

Although there have been many floras completed in Arizona, there have been no plant checklists or floristic studies done within twenty-five miles of the Wilderness (Moore and Cole 2004). In fact, most localities in western Arizona are sparsely documented botanically compared to the rest of the state. Prior to the creation of this flora, less than 40 plant species had been collected in the Hummingbird Springs Wilderness and nearby areas, with the most recent collection in 1996 by BLM botanist John Anderson (SEINet 2008). Floras completed nearest to HSW include the White Tank Mountains Regional Park and the Buckeye Hills

Recreational Area. A flora is in progress at the Eagletail Mountains Wilderness.

STUDY AREA

Overview—Hummingbird Springs Wilderness is located about 60 miles west of Phoenix in the Sonoran Desert, and about 11 miles north of Interstate 10 and the town of Tonopah. Nearby ranges include the Harquahala Mountains to the northwest, and the Eagletail Mountains to the southwest. The Wilderness boundary outlines over 31,000 acres and is accessible from the north and south by gravel roads. The topography varies greatly, containing 8 miles of the Big Horn Mountain Range with the peak elevation at Sugarloaf Mountain (3,418 ft) and the low valleys at 1,550 ft.

Seasonal water sources throughout the Wilderness include Hummingbird Springs, livestock tanks and washes. Several wells have been built in the past and still exist today for a variety of purposes. Within three miles of Sugarloaf Mountain is a large mine owned by the federal government, nicknamed the Belmont Pit. It actively mines gold, copper, silver, and lead (USBM 1994). Arizona had an extensive mining boom that started in the 1870s, and several inactive mines dot the area around the Wilderness (Trimble 2004).

Geology and Soils—The HSW contains six different geological units defined by geological age and type, ranging in age from the middle Pleistocene Epoch (0.78 to 0.13 Mya) to the early Proterozoic Eon (1650-1800 Mya). Volcanic rocks, granitoid rocks and older surficial deposits dominate the landscape of HSW. Other minor layers consist of sedimentary rocks, metamorphic rocks such as gneiss, and granitoid rocks such as granite, quartz diorite and gabbro (Reynolds 1988).

Two soil associations are dominant in Hummingbird Springs Wilderness. The first is the Gunsight-Rillito-Pinal Association (HA4) that includes well-drained, limey, gravelly soils on alluvial surfaces and valley slopes. Calcareous mixed alluvium resulting from volcanic rocks, schist, limestone, and granite formed the soils of HA4. Shallow depth and low water capacity in the Pinal soils restrict plant growth (Hendricks 1986). The second soil association, Lithic Camborthids-Rock Outcrop-Lithic Haplargids (HA6), consists of gravelled and cobbled shallow sloping soils, and rock outcrops on hills and low mountains. Because of the steep and rocky terrain, livestock grazing on this soil association is minimal. Weathered materials from granitic rocks, schists, basalt, volcanic tuffs and conglomerates, sandstone and some shale formed the soils of HA6 (Hendricks 1986).

Climate—The weather in central Arizona was dry and hot during the period of collection for this flora, which was conducted from the January 2006 to December 2007. The longest drought ever recorded in Arizona occurred from October 18, 2005 to March 11, 2006 lasting 143 days (Giblin 2006). HSW has a similar climate to that of the city of Phoenix, with the Wilderness climate being drier and less predictable from year to year. The average temperatures range from 106.5 °F in July to 36.4 °F in December, with recorded extremes of 121 °F and 14 °F (WRCC 2008). Precipitation averages from 1.18 inches (3 cm) in August to 0.03 inches (0.1 cm) in May with recorded extremes of 4.84 inches (12.3 cm) and 0.00 inches (0 cm) (WRCC 2008). In the town of Tonopah, 11 miles south of HSW,

temperatures reached a record high mean of 92.5 °F in the summer of 2006 (June, July, August) compared to the summer average of 89 °F. In the winter (December, January, February) of 2006, precipitation hit a record low of 1.05 inches (2.7 cm), compared to the winter average of 2.98 inches (7.6 cm) in Tonopah (WRCC 2008).

Fauna—The Sonoran Desert is home to a diversity of mammals, reptiles, birds and insects. Those noted while plant collecting include mule deer, jackrabbits, roadrunners, tarantulas, desert tortoises, rattlesnakes, and various other birds and lizards. Many other species typical of the Sonoran Desert are most likely present, including javelina, coyote and vultures.

Two introduced animals are also prominent in the landscape surrounding and inside the Wilderness: wild burros and cattle. About 1500 wild burros are estimated to live in Arizona. Since the land in the area is owned by the BLM, wild burro herds and the permits for cattle grazing are regulated by this agency. Although the HSW area is not managed for wild burros, a small herd (estimated at 47) has been documented in the Harquahala Mountains to the northwest. Another 100 burros do not fall into a particular herd, but roam the areas outside herd management (BLM 2008). While the Wild Horse and Burro Act of 1971 provides federal protection for wild burros, they cause problems for native wildlife and can therefore affect ecosystem health (Bleich 2005).

Cattle grazing became a large industry in Arizona in the 1880s and continues to varying degrees today (Trimble 2004). Due to the long-standing tradition of open cattle grazing, it is not surprising that when wilderness areas were created, grazing was not banned. In fact, according to the Wilderness Act of 1964, grazing levels established prior to wilderness designation must be maintained. Active sheep and cattle grazing is present in about 35% of wilderness areas in the western states, and threatens native plant and animal life (Cole and Landres 1996).

Three grazing allotments outlined by the BLM include parts of the HSW and the nearby land: Aguila, Ohaco and Echeverria. These areas are allowed a certain number of cattle per month within the assigned acreage according to the amount of forage available, measured in Animal Unit Months (AUMs) (Bedell 1992). In total, over 7000 AUMs are given for over 275,000 acres within and around HSW. The actual number of cattle present on these acres is 630, which are allowed to roam in and around the Wilderness (BLM RAS 2008).

Vegetation—The Sonoran Desert is a Tropical-Subtropical Desertland (Brown 1994). The Hummingbird Springs Wilderness boundary encompasses two distinct vegetation zones of the Sonoran Desert: Arizona Upland Sonoran Desertscrub (Fig. 1A), and Lower Colorado River Sonoran Desertscrub, as defined by Brown and Lowe (1980).

The HSW area primarily contains plant communities common to the Arizona Upland division of the Sonoran Desert. The landscape is a scrubland of armed leguminous trees and intervening spaces filled with perennial shrubs and cacti. The most common plant association in the HSW area is Paloverde-Cacti-Mixed Scrub, in which the dominant species are Paloverde (*Parkinsonia microphylla*), Saguaro (*Carnegiea gigantea*) and Creosote (*Larrea tridentata*). Many other species are common and can become dominant in localized areas including Triangle Leaf

Bursage (*Ambrosia deltoidea*), White Thorn Acacia (*Acacia constricta*), Teddy Bear Cholla (*Cylindropuntia bigelovii*; Fig. 1B), and Ocotillo (*Fouquieria splendens*).

Other plant associations in the area, in this Arizona Upland division, are less common but are present in small pockets. The eastern edge of the Wilderness contains a Jojoba-Mixed Scrub community, with the dominant species being Jojoba (*Simmondsia chinensis*), but also includes many of the species mentioned above. Other areas include stands of Creosote and Crucifixion Thorn (*Canotia holacantha*), or hillsides of Brittlebush (*Encelia farinosa*). Large Ironwood trees (*Olneya tesota*) are more commonly seen in the southern portion of the wilderness, along with Saguaro and perennial shrubs.

As a person travels south, it becomes evident that the plant communities are changing, becoming less dense and adapting to an area of lower elevation and drier climate. This transition between the two divisions of the Sonoran Desert is gradual and in HSW, plant associations of the two divisions can be found overlapping throughout its center section.

Across the Wilderness, ephemeral and annual species are present after late summer monsoons or winter rains, but the recent drought created a limited estimate of these species in this study. Those that are common to the Wilderness even in dry years include grasses such as *Schismus* spp., members of Boraginaceae such as *Cryptantha* spp., and members of Euphorbiaceae such as *Chamaesyce* spp.

The southeastern portion of the HSW is sparse and contains plant communities common to the Lower Colorado River division of the Sonoran Desert (Brown 1994). Sections of desert pavement dot the area, with expanses of perennial shrubs such as Creosote and White Bursage (*Ambrosia dumosa*) throughout. The larger washes in this area house other more water dependent species, such as Paloverde, White Thorn Acacia and Ironwood.

METHODS

Plants were collected in the field (Fig. 2A) at least once a month throughout the floristic study (January 2006 to December 2007), with more frequent collecting during peak growing seasons or after heavy rains. A total of 29 days were spent in the field gathering plants and hiking the Wilderness. With each collection, location and elevation were recorded using a GPS, and associated species, habitat description and relative abundance were noted. With the goal of visiting every section within the Wilderness boundary, a variety of vegetation zones were surveyed in all seasons as defined by different parameters such as elevation, aspect or soil. Some areas of the Wilderness were not surveyed due to limited access and time constraints.

Specimens were identified using *Arizona Flora* (Kearney and Peebles 1960) with appropriate revisions and updates from the Flora of Arizona Project in the *Journal of Arizona-Nevada Academy of Science* and *Canotia* (www.canotia.org). Nomenclature, author names and abbreviations follow the United States Department of Agriculture's National Plants Database (USDA 2008), with exceptions for certain species when the new treatments for Arizona were available. Experts including Elizabeth Makings and Dr. Leslie Landrum were consulted as needed for particular genera, and species identification was verified using the Arizona State University

(ASU) Herbarium collections. Over 800 voucher specimens were made and are housed in the ASU Herbarium.

Greenhouse Methods—In the fall of 2005, when the planning of the floristic study began, Arizona experienced the driest winter ever recorded. In dry years, the ephemerals in the area are not likely to germinate. To capture the diversity of the ephemerals, samples of the seed bank were collected and grown in a greenhouse on the ASU campus. Previous studies have shown that in desert soils, the seed bank is present in the top two centimeters of the soil (Reichman 1984). Samples were collected in the field twice in 2006 and twice in 2007, at various locations in the Wilderness (Fig. 2B). Several microhabitats were sampled with an effort made to minimize the impact of soil removal. The greenhouse conditions were maintained to mimic wet seasons in the field, with frequent watering and approximate field temperatures. Each soil sample was evenly distributed over a mix of sterile soil and coarse sand in a 13 by 9 inch tray, with a total of 29 sample trays and two control trays containing only soil and coarse sand (Fig. 1C). Soil samples were between 100 and 200 cm³. Specimens grown from seed were collected, pressed and identified in the same manner as the field collections as soon as they reached reproductive maturity. The greenhouse study began in February 2006 and continued through November 2007. Voucher specimens were made of each species from each sample site and are housed at the ASU Herbarium.

RESULTS AND DISCUSSION

Plant collecting in and around the boundaries of HSW yielded 864 individual collections. A total of 270 species were collected belonging to 64 families, including 199 genera (Table 1). Five families accounted for 46% of the collection: Asteraceae (38 genera, 49 species), Poaceae (20 genera and 31 species), Fabaceae (13 genera and 19 species), Boraginaceae (six genera and 13 species) and Euphorbiaceae (five genera and 12 species).

Table 1. Taxonomic* composition of the 864 collections from HSW.

| Taxonomic Group | Families | Genera | Species | | Species Total |
|-----------------------|-----------|------------|------------|------------|---------------|
| | | | Native | Introduced | |
| Pteridophyta | 1 | 4 | 5 | 0 | 5 |
| Lycopodiophyta | 1 | 1 | 1 | 0 | 1 |
| Pinophyta: Gnetopsida | 1 | 1 | 2 | 0 | 2 |
| Magnoliophyta | 61 | 193 | 243 | 19 | 262 |
| Magnoliopsida | 57 | 170 | 217 | 11 | 228 |
| Liliopsida | 4 | 23 | 26 | 8 | 34 |
| Column Total | 64 | 199 | 251 | 19 | 270 |

*Species characteristics from USDA PLANTS database (2008)

The origin of each species was determined using the USDA PLANTS database. Species are considered “native” when we presume they were present at the time of Columbus (USDA 2008). Introduced species (Table 2) reproduce spontaneously in the wild and are believed to have arrived in the U.S after the time of Columbus. Nineteen of the species collected (7%) are listed as introduced to Arizona, eight of these from Poaceae. One genus, *Cuscuta* is listed as a prohibited, restricted noxious weed in the U.S, even though it is a native species. In California, *Orobanche cooperi* is listed as a noxious weed due to its parasitic nature. All *Tamarix* species are listed as noxious weeds in several states including Nevada, but not in Arizona or California (USDA 2008).

Table 2. Introduced species collected in or around HSW.

| | |
|---|--------------------------------|
| <i>Amaranthus albus</i> | <i>Phalaris minor</i> |
| <i>Brassica tournefortii</i> | <i>Polygonum argyrocoleon</i> |
| <i>Bromus rubens</i> | <i>Polypogon monspeliensis</i> |
| <i>Chenopodium murale</i> | <i>Schismus arabicus</i> |
| <i>Cynodon dactylon</i> | <i>Schismus barbatus</i> |
| <i>Echinochloa crus-galli</i> | <i>Sisymbrium altissimum</i> |
| <i>Eragrostis cilianensis</i> | <i>Sisymbrium irio</i> |
| <i>Erodium cicutarium</i> | <i>Sonchus oleraceus</i> |
| <i>Gossypium hirsutum</i> (agricultural escape) | <i>Tamarix chinensis</i> |
| <i>Malva parviflora</i> | |

The Arizona Wildlands Invasive Plant Working Group (AWIPWG), a group made up of over 20 federal and state agencies, created a list recording invasive species, with rankings of high, medium, and low, depending on their impact and ability to invade plant communities. Species that are of high concern are *Bromus rubens* and *Tamarix* spp. due to their severe ecological impact, wide distribution, and high rates of dispersal and establishment. Species of medium concern that have substantial ecological impacts, moderate rates of dispersal often enhanced by disturbance, and a generally limited distribution are: *Brassica tournefortii*, *Cynodon dactylon*, *Erodium cicutarium*, *Schismus* spp. and *Sonchus oleraceus* (AWIPWG 2008).

Invasive plants reported in Sonoran Desert wildernesses such as *Bromus rubens* and *Brassica tournefortii* can affect fire regimes. Others, like *Tamarix* spp., alter hydrology (Marler 2000). According to a recent study, invasive species are not in the top ten priorities for wilderness management for 90% of managers surveyed in the southwest. About 40% of respondents did not even have any information about invasive species in their wilderness areas (Marler 2000). HSW was included on the list of participating wilderness areas in the survey. Thus, this is the first report of invasive species within the HSW.

In comparison to other published floras in the Sonoran Desert, the flora of HSW has an average to low percent of invasive species (7%), most likely due to its

distance from major cities or lack of water sources. Other invasive species percentages include 10% at Phoenix South Mountain Park (Daniel and Butterwick 1992), 11% at Sierra Estrella Mountains Regional Park (Sundell 1974), 6.7% at White Tank Mountains Regional Park (Keil 1973), and 8% at McDowell Mountain Regional Park (Lane 1981).

In addition to collecting plants within the HSW, plants were collected in the surrounding areas when opportunities presented themselves. These collections added a few species to the total found and are considered to probably grow within the HSW. One species that was found in abundance outside the Wilderness but not found within is *Castela emoryi*. It is included in the flora list as a probable species.

This study adds no new or threatened species to the flora of Arizona but there are a few notable collections. One species, *Glinus radiatus* (spreading sweetjuice, Molluginaceae; Fig. 1D) has only been collected a few times in the state in places over 50 miles from HSW in areas near McDowell Mountain Park, Nogales and Cabreza Prieta Game Range (SEINet 2008). It is usually found at the bottom of drying ponds or tanks, and flowers during late summer. In HSW it was found in Dead Horse Tank, a large dry cow tank, in May 2007. This collection may represent an extension of its range.

Another interesting collection was of *Gossypium hirsutum* (upland cotton, Malvaceae), found in October 2006, in a roadside wash. Cotton is grown in fields south of the Wilderness near Tonopah and seems to have migrated via wind or by vehicle to the vicinity of HSW. This agricultural escape has not been seen in other floras and *Gossypium hirsutum* has only been collected in the wild twice in Arizona (SEINet 2008). Cotton has been an important crop in Arizona since 1916, and in 2007 about 190,000 acres were grown. Over 40 strains of cotton are in use across Arizona, but most of these are varieties of *Gossypium hirsutum* (CALSMART 2008).

Previous plant collections in HSW and the surrounding area are sparse. In comparing the species previously collected with the more complete checklist created as a result of this study, it was found that nearly all the species were recollected. Those that were not found in the present study are: *Gaillardia arizonica* (Asteraceae), *Rafinesquia californica* (Asteraceae), *Astragalus nuttallianus* (Fabaceae), *Calliandra eriophylla* (Fabaceae), and *Prunus fasciculata* (Rosaceae). These plants may still be present in HSW but perhaps were not found due to variations in climate, collection locations, or accessibility. For example, *R. californica* is most likely present but was not found due to the drier than average climate conditions. Another possibility is that these species are locally uncommon or no longer occur in the area.

Two areas thought to be similar to the HSW are the Kofa National Wildlife Refuge (KNWR), which is located to the southwest of HSW and has a high elevation of 4,877 ft, and the Sierra Estrella Mountain Range (SEMR), located to the southeast with a high elevation of 4,511 ft. These two places are also in the Sonoran Desert and have similar climate conditions although their elevation is higher than that of HSW. Twenty-seven species that have been collected during this study, in the HSW vicinity, have not been found in either the Kofa or Sierra Estrella regions (Russo 1987, SEINet 2008, Sundell 1974). These species are listed in Appendix A

and represent those species that are perhaps difficult to find, rare or uncommon or are outside of their usual range. For example, one of these species, *Echinomastus johnsonii*, is typically found in the Mojave Desert and is therefore uncommon in the Sonoran Desert.

Of the 186 species found in both the KNWR and the SEMR, 37 were not found in HSW (Russo 1987, SEINet 2008, Sundell 1974). These plants are likely to be found in the HSW area, and are predicted to be part of the HSW flora (Appendix A). Future collectors are urged to search for them.

This flora study aimed to collect in all habitats across the HSW area, but inevitably, not every inch of the Wilderness can be explored. The western area of the Wilderness is difficult to access, as are the jagged peaks in the southeastern portion. Also, the drought during the study greatly restricted the diversity of winter and spring ephemerals. Continuing collection of this area and those places nearby will create a more complete picture of the flora.

Greenhouse Results and Discussion—The soil samples collected from HSW contained enough viable seeds to produce 374 greenhouse collections with a total of 36 species plus two species that are unlikely to have come from the field: *Oxalis corniculata* and *Nicotiana benthamniana*. The first is a greenhouse weed and the second escaped from another study in the greenhouse.

Only one out of the seven soil locations was free of any invasive species. A little over 25% (11) of the species collected are invasive species. Six species were not collected in the field but are now presumed to grow in HSW. Appendix B contains a complete list of greenhouse species.

The greenhouse study was carried out in order to add a few more species to the flora list that may not be collected in a drought year. It was a small study and only one type of climate regime was implemented. In order to germinate more species, many more soil samples should be taken, using various treatments to generate the largest amount of species. One species, *Sonchus oleraceus*, was originally present in only one tray until it spread profusely to every other tray in the room. In future studies, great care should be taken to avoid contamination by collecting specimens before mature seeds are produced. Another species, *Oxalis corniculata*, most likely does not occur in the HSW area, though it was present in every sample tray. It is a common greenhouse weed and spreads quickly. Towards the end of the study, *Sonchus* and *Oxalis* were weeded out in order to stop their continuing germination cycle. The two control trays containing sterile soil had only these two problematic species, illustrating that they originated from the greenhouse and not from the soil samples.

CATALOG OF THE VASCULAR FLORA OF THE HUMMINGBIRD SPRINGS WILDERNESS

Taxa are arranged alphabetically by family, genus and then by species. Nomenclature, author names and abbreviations follow the USDA PLANTS Database (2008), with exceptions for certain species when the new treatments for Arizona were available in the *Journal of Arizona-Nevada Academy of Science* and in *Canotia*. This database also provided common names and the origin of each species. Parts of the checklist are described below:

- A. Plants that are considered non-native in North America, are listed as "INTRODUCED" after the authority. Plants are called native if they are presumed to have been present before the time of Columbus.
- B. Common names are given as listed in USDA PLANTS Database (2008).
- C. General habitat is given along with collection localities (see Fig. 2C) to indicate where the species is most likely to be found. Collection localities are variable in size and sometimes cover several hectares.
- D. Collection numbers are from the field unless preceded by "G" which indicates they are collections from the greenhouse study. The primary collector for all collections is the author and all are deposited at the Arizona State University Herbarium.
- E. The abundance determinations are based on field observations taken over the duration of the study (January 2006 to December 2007) and is rated subjectively using terms and definitions adapted from Palmer et al. (1995) are as follows: Abundant = dominant or co-dominant in one or more common habitats; Frequent = easily found in one or more common habitats, but not dominant; Occasional = widely scattered but not difficult to find; Infrequent = difficult to find with few individuals or colonies, found in several locations; Rare = very difficult to find, limited to one/few locations or uncommon habitats; Absent = found only in a previous survey from the same or similar sites.

Acanthaceae

Justicia californica (Benth.) D. Gibson. Beloperone. Large gravel wash. Infrequent. OCW: 393, 718.

Agavaceae

Yucca elata (Engelm.) Engelm. Soap tree yucca. Gravel roadside. Rare. AG: 599b.

Amaranthaceae

Amaranthus albus L. INTRODUCED. Prostrate pigweed. Flooded roadside, large gravel wash. Frequent. SPR, EER, DHT: 200, 283, 368, 760, G59.

Amaranthus fimbriatus (Torr.) Benth. ex S. Watson. Fringed amaranth. Flooded roadside, cow tank. Occasional. SPR, EER, DHT: 285, 351, 805.

Amaranthus palmeri S. Watson. Careless weed. Flooded roadside, tank. Infrequent. SPR, EER: 286, 353.

Tidestromia lanuginosa (Nutt.) Standl. Woolly tidestromia. Gravel roadside, large wash. Frequent. SPR, MT: 297, 333, 343, 361, 416.

Anacardiaceae

Rhus aromatica Aiton. Fragrant sumac. North facing canyon. Rare. SM: 804.

Apiaceae

Bowlesia incana Ruiz & Pav. Hoary bowlesia. Dry rocky area, large wash. Occasional. SPR: 646, 678.

Yabea microcarpa (Hook. & Arn.) Koso-Pol. False carrot. North rocky slope. Occasional. SM: 635.

Daucus pusillus Michx. American wild carrot. Gravel road, ridgeline, large wash. Frequent. SPR, SM, MT: 75, 153, 203, 674, 706, G53, G97.

Aristolochiaceae

Aristolochia watsonii Woot. & Standl. Watson's dutchman's pipe. Large wash. Rare. EER: 299.

Asclepiadaceae

Asclepias nyctaginifolia A. Gray. Mojave milkweed. Small wash. Rare. MT: 433.

Matelea parviflora (Torr.) Woodson. Spearleaf. Dry rocky north facing slope. Rare. SM: 448.

Sarcostemma cynanchoides Decne. Fringed twinevine. Dry wash. Infrequent. DHT: 363.

Asteraceae

Acamptopappus sphaerocephalus (Harv. & A. Gray ex. A. Gray) A. Gray. Rayless goldenhead. Gravel road. Infrequent. MT: 595.

Acourtia nana (A. Gray) Reveal & King. Dwarf desert peony. Dusty roadside. Rare. AG: 777.

Acourtia wrightii (A. Gray) Reveal & King. Brownfoot. Low desert hills, large gravel wash. Occasional. MT, OCW, SPR: 16, 399, 431, 757.

Adenophyllum porophylloides (A. Gray) Strother. Dogweed. Low desert hills, large gravel wash, dry rocky north facing slope. Frequent. MT, SM, SPR: 24, 426, 430, 449, 521.

Ambrosia ambrosioides (Cav.) Payne. Ambrosia leaf bur ragweed. Large gravel wash. Frequent. SPR, OCW: 128, 181, 748.

Ambrosia deltoidea (Torr.) Payne. Triangle bur ragweed. Rocky slopes, dry tank bed, large gravel wash. Abundant. MT, DHT, SPR, OCW: 27, 61, 114, 215, 741.

Ambrosia dumosa (A. Gray) Payne. Burrobush. Along ridgeline, large wash, gravel roadside. Frequent. SPR, SM: 17, 86, 152, 222, 334, 693.

Artemisia ludoviciana Nutt. White sagebrush. Rocky area. Rare. SM: 462, 802.

Baccharis salicifolia (Ruiz & Pav.) Pers. Mulefat. Rocky bank of large wash. Rare. SPR: 479.

Baccharis sarothroides A. Gray. Desert broom. Rocky slopes, gravel parking lot, large wash. Frequent. MT, DHT, OCW: 29, 365, 432, 727, G266.

Baileya multiradiata Harv. & A. Gray ex A. Gray. Desert marigold. Gravel roadside. Frequent. EER, MT: 45, 277, 704.

Bebbia juncea (Benth.) Greene. Sweetbush. Rocky slopes, ridgeline, large wash. Abundant. MT, SPR, OCW: 34, 225, 238, 359, 747.

Brickellia coulteri A. Gray. Coulter's brickell bush. Large gravel wash. Occasional. OCW, SM, SPR: 130, 392, 442, 820.

Brickellia frutescens A. Gray. Shrubby brickell bush. Rocky ridgeline, large wash. Occasional. SPR, OCW, MT, SM: 100, 163, 214, 397, 422, 434, 459, 819.

Chaenactis stevioides Hook. & Arn. Esteve's pincushion. Flat dry rocky area, large wash. Infrequent. SPR, EER: 649, 682, 850.

Cirsium neomexicanum A. Gray. New Mexico thistle. Rocky ridgeline, large wash. Occasional. SM: 162, 564, 602.

Encelia farinosa A. Gray ex Torr. Brittlebush. Washes, north gravel slope. Abundant. SPR, OCW, MT: 20, 101.

Ericameria laricifolia (A. Gray) Shinnars. Turpentine bush. Large gravel wash, rocky area. Rare. OCW, SM: 402, 453, 818.

Erigeron divergens Torr. & A. Gray. Spreading fleabane. South slope. open rocky area. Infrequent. SM, MT: 542, 697.

Erigeron lobatus A. Nelson. Lobed fleabane. Rocky ridgeline, small wash. Infrequent. SM: 96, 506.

Filago arizonica A. Gray. Arizona cottonrose. Greenhouse Study. Occasional. MT, SPR: G93, G303, G72, G118, G83.

Filago californica Nutt. California cottonrose. South slope, open rocky area. Infrequent. SM: 552, G310.

Gutierrezia sarothrae (Pursh) Britton & Rusby. Broom snakeweed. Low desert hills, small wash. Abundant. MT, SM: 7, 68, 106, 379, 440, 796.

Gutierrezia serotina Greene. Late snakeweed. Dusty roadside. Rare. AG: 776.

- Hymenoclea monogyra* Torr. & A. Gray. Singlewhorl burrobrush. Large wash. Infrequent. EER: 383.
- Hymenoclea salsola* Torr. & A. Gray. Burrobrush. Large wash. Infrequent. EER: 589.
- Isocoma acradenia* (Greene) Greene. Alkali goldenbush. Roadside. Infrequent. EER: 318.
- Laemecia coulteri* (A. Gray) G. L. Nesom. Coulter's horseweed. Large wash. Infrequent. SPR: 196, G250.
- Lasthenia californica* DC. ex Lindl. California goldfields. Gravel road, ridgeline, dry tank bed, south slope. Infrequent. DHT, SM: 76, 119, 549.
- Machaeranthera pinnatifida* (Hook.) Shinnars. Lacy tansyaster. Low desert hills, large wash, rocky ridgeline. Infrequent. SPR, SM, MT: 6, 155, 234, 266, 561.
- Machaeranthera tagetina*. Greene. Mesa tansyaster. Large gravel wash. Infrequent. EER: 386.
- Microseris lindleyi* (DC.) A. Gray. Lindley's silverpuff. Gravel wash. Infrequent. EER: 847.
- Monoptilon belliioides* (A. Gray) H. M. Hall. Mojave desertstar. Flat dry rocky area, wash. Occasional. SM, SPR, EER: 534, 648, 853.
- Pectis papposa* Harv. & A. Gray. Manybristle chinchweed. Rocky slopes, wash, disturbed areas. Frequent. MT, EER, SPR, DHT: 44, 258, 314, 323, 375, 767, 837.
- Perityle emoryi* Torr. Emory's rockdaisy. Large gravel wash, rocky slope. Occasional. SPR, SM: 154, 224, 614, 669, 788.
- Pluchea sericea* (Nutt.) Coville. Arrowweed. Large gravel wash. Infrequent. SPR: 150, 195.
- Porophyllum gracile* Benth. Slender poreleaf. Large wash, gravel roadside. Occasional. MT, SPR: 129, 233, 340.
- Psilostrophe cooperi* (A. Gray) Greene. Whitestem paperflower. Wash, gravel roadside. Occasional. MT, SPR: 259, 345.
- Rafinesquia neomexicana* A. Gray. New Mexico plumeseed. Dry cow tank. Infrequent. DHT: 861.
- Senecio* sp. L. Ragwort. Infrequent. SM: 821a.
- Senecio flaccidus* Less. var. *monoensis* (Greene) B. L. Turner & T. M. Barkley. Smooth threadleaf ragwort. Large gravel wash. Infrequent. EER: 716.
- Senecio lemmonii* A. Gray. Lemmon's ragwort. Large gravel wash, rocky slope. Occasional. SPR, SM: 232, 525, 606, 809.
- Sonchus oleraceus* L. INTRODUCED. Common sowthistle. Large gravel wash. Infrequent. SPR: 188, 764, G290, G199.
- Stephanomeria pauciflora* (Torr.) A. Nelson. Brown plume wirelettuce. Rocky slope, wash. Abundant. MT, SPR, EER, SM, OCW: 58, 229, 300, 336, 467, 722.
- Stylocline micropoides* A. Gray. Woolly head neststraw. Gravel wash. Occasional. EER: 851.
- Symphyotrichum divaricatum* (Nutt.) G. L. Nesom. Annual saltmarsh aster. Greenhouse Study. Infrequent. MT, SPR: G208, G193, G194, G187.
- Trichoptilium incisum* (A. Gray) A. Gray. Yellow dome. Low desert hills, washes. Rare. SPR: 1.
- Trixis californica* Kellogg. American threefold. Rocky slopes, gravel parking lot, large wash. Frequent. MT, SPR, OCW: 28, 127, 213, 321, 692, 743.
- Viguiera parishii* Greene. Parish's goldeneye. Rocky slopes, gravel parking lot, wash. Frequent. MT, SM, OCW: 9, 33, 94, 167, 230, 518, 750.
- Xylorhiza tortifolia* (Torr. & A. Gray) Greene. Mojave woodyaster. Large rocky wash, gravel slope. Rare. SM, MT: 532, 540, 863.

Berberidaceae

- Berberis haematocarpa* Woot. Red barberry. Rocky slope. Rare. SM: 473, 605, 822.

Bignoniaceae

- Chilopsis linearis* (Cav.) Sweet. Desert willow. Large gravel wash. Rare. EER: 717.

Boraginaceae

- Amsinckia menziesii* (Lehm.) A. Nelson & J. F. Macbr. Menzies' fiddleneck. Gravel roadside, large wash. Abundant. EER, SPR, SM, OCW: 48, 145, 492, 515, 522, 548, 654, 658, 756, G36, G291.
- Amsinckia tessellata* A. Gray. Bristly fiddleneck. Large open gravel wash. Rare. EER: 590.
- Cryptantha* sp. Lehm. ex G. Don. *Cryptantha*. Gravel roadside. EER: 53b.

- Cryptantha angustifolia* (Torr.) Greene. Panamint cryptantha. Large open gravel wash. Rare. EER: 574b.
- Cryptantha barbiger* (A. Gray) Greene. Bearded cryptantha. Dry tank bed, large wash. Abundant. DHT, SPR, EER, SM, MT, OCW: 123, 131, 185, 565, 569, 574a, 624, 651, 665, 671, 684, 699, 710, 719, G296.
- Cryptantha maritima* (Greene) Greene. Guadalupe cryptantha. North rocky slope, large wash. Infrequent. SM, SPR: 621, 685.
- Cryptantha micrantha* (Torr.) I. M. Johnst. Redroot cryptantha. Large gravel wash. Infrequent. EER: 593.
- Cryptantha pterocarya* (Torr.) Greene. Wingnut cryptantha. Gravel road, ridgeline, large wash. Infrequent. SM, SPR, EER: 72, 512, 670, 848.
- Harpagonella palmeri* A. Gray. Palmer's grappling hook. Rocky slopes. Occasional. SM: 556, 626, G317.
- Pectocarya* sp. DC. ex Meisn. Combseed. Flat wash. MT: 54.
- Pectocarya platycarpa* (Munz. & I. M. Johnst.) Munz. & I. M. Johnst. Broadfruit combseed. Gravel roadside, dry tank bed, large wash. Frequent. EER, DHT, SPR: 51, 121, 583, 656, G4, G307.
- Pectocarya recurvata* I. M. Johnst. Curvenut combseed. Gravel road, ridgeline, south slope, rocky wash. Abundant. MT, EER, SM, DHT, SPR: 42, 52, 80, 89, 491, 495, 533, 568, 620, 655, G306, G309.
- Plagiobothrys* sp. Fisch. & C. A. Mey. Popcorn flower. Flat wash. MT: 55.
- Plagiobothrys arizonicus* (A. Gray) Greene ex A. Gray. Arizona popcorn flower. Gravel roadside, rocky wash, south slope. Occasional. MT, EER, DHT: 47, 496, 530, 546, G325.
- Plagiobothrys jonesii* A. Gray. Mojave popcorn flower. Large gravel wash. Infrequent. SPR: 184.
- Tiquilia canescens* (DC.) A. T. Richardson. Woody crinklemat. Dry rocky north slope, gravel roadside. Occasional. SM, MT: 450, 864.

Brassicaceae

- Arabis* sp. L. Rockcress. SM: 821b.
- Arabis perennans* S. Watson. Perennial rockcress. Rocky outcrop near wash. Infrequent. SM: 446, 508.
- Brassica tournefortii* Gouan INTRODUCED. Asian mustard. Large gravel wash, rocky area. Occasional. SPR, EER: 183, 484, 676, G46, 79d, G365, G366.
- Descurainia pinnata* (Walter) Britton. Western tansy mustard. Large wash. Rare. SPR: 668.
- Draba cuneifolia* Nutt. ex Torr. & A. Gray. Wedgeleaf draba. South slope, open rocky area. Rare. SM: 537, 550.
- Guillenia lasiophylla* (Hook. & Arn.) Greene. California mustard. Gravel wash. Rare. MT: 858, G63, G68, G82, G102, G104.
- Lepidium lasiocarpum* Nutt. Shaggyfruit pepper weed. Gravel road, along ridgeline, dry tank bed, large gravel wash. Abundant. SM, DHT, SPR, EER, MT: 74, 122, 148, 235, 490, 535, 555, 567, 575, 657, 707, G312, G315, G258.
- Lesquerella gordonii* (A. Gray) S. Watson. Gordon's bladderpod. Rocky wash, open gravel wash. Occasional. SM, EER: 493, 513, 588.
- Sisymbrium altissimum* L. INTRODUCED. Tall tumble mustard. Greenhouse Study. Rare. MT: G139.
- Sisymbrium irio* L. INTRODUCED. London rocket. Low desert hills, dry tank bed, large wash. Occasional. DHT, SPR, SM: 5, 115, 566, 659, G121, G364.
- Thysanocarpus curvipes* Hook. Sand fringe pod. Rocky wash. Infrequent. SM: 494, 499, 623, 633.

Cactaceae

- Carnegiea gigantea* (Engelm.) Britton & Rose. Saguaro. Open gravel. Abundant. SPR, OCW: 176, 754.
- Cylindropuntia acanthocarpa* (Engelm. & Bigelow) F. M. Knuth. Buck-horn cholla. Gravel roadside. Abundant. SPR: 349, 835.
- Cylindropuntia bigelovii* (Engelm.) F. M. Knuth. Teddy bear cholla. Large wash. Abundant. MT: 160.

Cylindropuntia leptocaulis (DC.) F. M. Knuth. Christmas cactus. Along ridgeline, gravel wash, roadside. Frequent. SM, SPR: 83, 251, 356, 436, 528.

Cylindropuntia ramosissima (Engelm.) F. M. Knuth. Pencil cholla. Dry gravel. Infrequent. SPR: 836.

Echinocereus engelmannii (Parry ex Engelm.) Lem. Engelman's hedgehog cactus. Rocky slope. Occasional. SM: 562.

Echinomastus johnsonii (Parry ex Engelm.) E.M.Baxter. Johnson's fishhook cactus. Rocky south slope. Infrequent. MT: 596.

Ferocactus cylindraceus (Engelm.) Orcutt. California barrel cactus. Gravel wash. Frequent. SPR: 178.

Mammillaria grahamii Engelm. Graham's nipple cactus. Rocky area, ridgeline. Frequent. SM: 452, 829.

Opuntia chlorotica Engelm. & Bigelow. Dollarjoint pricklypear. Open gravel slope. Frequent. MT, SM: 695, 834.

Opuntia engelmannii Salm-Dyck ex Engelm. Cactus apple. Gravel wash, flat rocky area. Frequent. SM: 263, 601.

Campanulaceae

Nemacladus glanduliferus Jeps. Glandular threadplant. Large gravel wash. Rare. SPR, EE: 143, 845.

Caryophyllaceae

Silene antirrhina L. Sleepy silene. Large gravel wash, north rocky slope. Occasional. SPR, SM, OCW: 134, 147, 220, 616, 636, 681, 732, G67.

Celastraceae

Canotia holacantha Torr. Crucifixion thorn. Gravel wash, rocky area. Occasional. MT, SM: 246, 252, 428, 472.

Chenopodiaceae

Atriplex canescens (Pursh) Nutt. Fourwing saltbush. Along large gravel wash. Infrequent. SM: 810.

Chenopodium berlandieri Moq. Pitseed goosefoot. Large gravel wash. Infrequent. SPR: 193.

Chenopodium murale L. INTRODUCED. Nettleleaf goosefoot. Flat dry rocky area. Infrequent. SPR: 661.

Monolepis nuttalliana (Schult.) Greene. Nuttall's poverty weed. Large wash. Rare. SPR: 664.

Crossosomataceae

Crossosoma bigelovii S. Watson. Ragged rockflower. Large gravel wash, north rocky slope. Infrequent. OCW, SM: 391, 454, 456, 519, 612, 725.

Cucurbitaceae

Brandegea bigelovii (S. Watson) Cogn. Desert starvine. Wet area, cow tank. Infrequent. SPR: 772.

Cuscutaceae

Cuscuta umbellata Kunth. Flatglobe dodder. Gravel roadside. Rare. MT: 862.

Ephedraceae

Ephedra aspera Engelm. ex S. Watson. Rough jointfir. Low wash, rocky slope. Frequent. SPR, MT, SM: 19, 60, 486.

Ephedra nevadensis S. Watson. Nevada jointfir. Rocky slopes, gravel parking lot, large gravel wash. Frequent. MT, SM: 32, 138, 509, 511.

Euphorbiaceae

Argythamnia lanceolata (Benth.) Mull. Arg. Narrowleaf silverbush. Rocky slopes, gravel parking lot, roadside, large rocky wash. Frequent. MT, SPR, SM: 12, 25, 136a, 268, 339, 437, 485, 517.

- Argythamnia neomexicana* Mull. Arg. New Mexico silverbush. Rocky slopes, large gravel wash, dry tank bed, roadside. Frequent. MT, DHT, EER, SPR, SM: 13, 65, 124, 136b, 256, 311, 327, 489, 765.
- Chamaesyce abramsiana* (L. C. Wheeler) Koutnik. Abram's sandmat. Gravel roadside, large wash, disturbed area, near cow tank. Frequent. MT, EER, DHT, SPR: 294, 315, 367, 770b.
- Chamaesyce albomarginata* (Torr. & A. Gray) Small. White margin sandmat. Gravel wash. Frequent. MT, EER: 257, 435a, 580.
- Chamaesyce arizonica* (Engelm.) Arthur. Arizona sandmat. Ridge, rocky area, north slope. Frequent. MT, SM: 360, 463, 634, 782.
- Chamaesyce micromera* (Boiss. ex Engelm.) Woot. & Standl. Sonoran sandmat. Wet area, cow tank nearby. Infrequent. SPR: 770a.
- Chamaesyce pediculifera* (Engelm.) Rose & Standl. Carrizo mountain sandmat. Small flat wash, gravel roadside, cow tank, rocky area. Frequent. MT, SPR, SM, EER, OCW: 103, 133, 274, 338, 355, 403, 457, 592, 723.
- Chamaesyce polycarpa* (Benth.) Millsp. ex Parish. Smallseed sandmat. Large gravel wash, rocky ridgeline, near road, wet area near cow tank. Frequent. SPR, MT: 205, 240, 279, 329, 358, 771.
- Chamaesyce setiloba* (Engelm. ex Torr.) J. B. S. Norton. Yuma sandmat. disturbed muddy area, large gravel wash. Frequent. DHT, EER, MT: 374, 387, 404, 419, 435b.
- Euphorbia eriantha* Benth. Beetle spurge. Rocky ridgeline, gravel roadside. Occasional. SPR, SM: 241, 332, 466, 560, 789.
- Tetracoccus hallii* Brandegee. Hall's shrubby spurge. Large gravel wash, gravel roadside, dry rocky area. Occasional. SPR: 144, 189, 341, 481, 643, 840.
- Tragia nepetifolia* Cav. Catnip noseburn. Shaded gravel wash crossing the road. Rare. MT: 779.

Fabaceae

- Acacia constricta* Benth. Whitethorn acacia. Low desert hills, gravel wash, gravel roadside. Abundant. SPR, MT, OCW: 23, 208, 247, 298, 745.
- Acacia greggii* A. Gray. Catclaw acacia. Large gravel wash, disturbed muddy area. Abundant. SPR, DHT, OCW, SM: 210, 250, 364, 742, 794.
- Dalea mollis* Benth. Hairy prairie clover. Wash, south slope, flat dry rocky area. Infrequent. SM, SPR: 10, 558, 642.
- Desmodium procumbens* (Mill.) Hitchc. Western trailing ticktrefoil. North facing canyon. Rare. SM: 787.
- Hoffmannseggia glauca* (Ortega) Eifert. Indian rushpea. Flat dusty area, roadside. Rare. AG: 599, 775.
- Lotus humistratus* Greene. Foothill deervetch. Rocky gentle slope, large gravel wash. Occasional. SM, EER, SPR, MT: 488, 584, 672, 708, G338.
- Lotus rigidus* (Benth.) Greene. Coastal bird's foot trefoil. Large rocky wash. Rare. SM, OCW: 516, 720.
- Lotus salsuginosus* Greene. Shrubby deervetch. Large wash. Infrequent. SPR: 673, 680.
- Lotus strigosus* var. *tomentellus* (Nutt.) Greene. Strigose bird's foot trefoil. Large wash. Infrequent. SPR: 679.
- Lupinus shockleyi* S. Watson. Purple desert lupine. Moist cow tank bed. Rare. DHT: 860.
- Lupinus sparsiflorus* Benth. Coulter's lupine. Large wash. Infrequent. EER, MT: 582, 598, 849.
- Marina parryi* (Torr. & A. Gray) Barneby. Parry's false prairie clover. South slope, large gravel wash, ridge. Frequent. SM, SPR, MT, EER, SM: 22, 92, 228, 357, 381, 405, 690, 803.
- Olneya tesota* A. Gray. Desert ironwood. Gravel road, large gravel wash. Abundant. MT, SPR, OCW: 175, 204, 737.
- Parkinsonia florida* (Benth. ex A. Gray) S. Watson. Blue paloverde. Roadside, recently flooded, large gravel wash. Abundant. EER, SPR, OCW: 284, 320, 739.
- Parkinsonia microphylla* Torr. Yellow paloverde. Gravel wash, dry tank bed. Abundant. SPR, DHT, OCW: 170, 182, 712, 753.
- Phaseolus filiformis* Benth. Slimjim bean. Rocky area, north rocky slope. Infrequent. SM: 470, 630, 815.

Prosopis velutina Woot. Velvet mesquite. Gravel road, large wash. Abundant. MT, SPR, OCW: 174, 179, 662, 746.

Senna covesii (A. Gray) Irwin & Barneby. Coues' cassia. wash, rocky slopes, gravel parking lot, disturbed muddy area. Frequent. MT, SPR, DHT: 21, 31, 64, 104, 226, 276, 370.

Vicia ludoviciana Nutt. ssp. *ludoviciana*. Louisiana vetch. North rocky slope. Rare. SM: 608.

Fagaceae

Quercus turbinella Greene. Sonoran scrub oak. Large rocky wash. Rare. SM: 520, 798.

Fouquieriaceae

Fouquieria splendens Engelm. Ocotillo. South gravel slope, wash. Abundant. MT, SPR: 11, 173, 694.

Gentianaceae

Centaurium calycosum (Buckley) Fernald. Arizona centaury. Large gravel wash. Infrequent. SPR: 180.

Geraniaceae

Erodium cicutarium (L.) L'Her. ex Aiton. INTRODUCED. Redstem stork's bill. Gravel roadside, gravel wash, south rocky slope. Abundant. EER, MT, SPR, SM: 46, 56, 198, 545, G136, G269.

Erodium texanum A. Gray. Texas stork's bill. South slope, rocky area. Occasional. SM, SPR: 544, 653.

Hydrophyllaceae

Eucrypta chrysanthemifolia. (Benth.) Greene. Spotted hideseed. Large wash. Infrequent. SPR: 677.

Eucrypta micrantha (Torr.) A. Heller. Dainty desert hideseed. Gravel slope. Occasional. SM: 536.

Nama hispidum A. Gray. Bristly nama. Large open gravel wash. Occasional. EER: 576.

Phacelia sp. Juss. *Phacelia*. SM, EER: 541, 855, 857.

Phacelia crenulata Torr. ex S. Watson. Cleftleaf wild heliotrope. Large open gravel wash, north rocky slope. Occasional. EER, MT, SM: 572, 597, 622.

Phacelia distans Benth. Distant phacelia. Large open gravel wash, north rocky slope. Occasional. EER, SM, SPR: 581, 619, 647.

Phacelia pedicellata A. Gray. Pedicellate phacelia. North rocky slope. Infrequent. SM: 637.

Pholistoma auritum (Lindl.) Lilja. Blue fiesta flower. Rocky area, near small wash. Occasional. SM: 505.

Krameriaceae

Krameria erecta Willd. ex Schult. Littleleaf ratany. Gravel roadside. Frequent. SPR: 761.

Krameria grayi Rose & Painter. White ratany. Rocky slope, ridgeline, south gravel slope. Frequent. MT, SM, SPR: 62, 87, 166, 177, 264.

Lamiaceae

Hyptis emoryi Torr. Desert lavender. Rocky slopes, gravel parking lot, large gravel wash. Frequent. MT, SPR, OCW: 41, 137, 199, 726.

Monardella arizonica Epling. Arizona monardella. Rocky area. Rare. SM: 475, 799.

Salazaria mexicana Torr. Mexican bladdersage. Small wash, large gravel wash, gravel roadside. Frequent. MT, SPR, EER, OCW, SM: 69, 109, 141, 301, 348, 698, 752, 785.

Salvia columbariae Benth. Chia. Large gravel wash. Infrequent. SPR, EER: 151, 192, 586, 666, 686.

Liliaceae

Dichelostemma capitatum (Benth.) Alph. Wood. Bluedicks. Rocky gentle slope, near wash. Infrequent. SM: 487, 500.

Loasaceae

Petalonyx thurberi A. Gray. Thurber's sandpaper. Large wash. Rare. EER: 305, 380.

Malpighiaceae

Janusia gracilis A. Gray. Slender janusia. Rocky slope, large wash, gravel roadside. Frequent. MT, SPR, SM: 265, 322, 427, 793, 839.

Malvaceae

Abutilon incanum (Link) Sweet. Pelotazo. Small gravel flat wash, gravel roadside, rocky slope. Frequent. MT, OCW, SM: 107, 262, 278, 296, 406, 439, 744, 831.

Gossypium hirsutum L. AGRICULTURAL ESCAPE. Upland cotton. Large wash. Rare. EER: 382.

Herissantia crispa (L.) Briz. Bladder mallow. Large gravel wash. Occasional. OCW: 390, 730.

Hibiscus coulteri Harv. ex A. Gray. Desert rosemallow. Gravel wash, north rocky slope. Infrequent. OCW, SM: 443, 640.

Malva parviflora L. INTRODUCED. Cheeseweed mallow. Flat dry rocky area. Occasional. SPR: 660.

Sphaeralcea ambigua A. Gray. Desert globemallow. Rocky slope, rocky ridgeline, large gravel wash, wet cow tank near road. Frequent. MT, SPR: 63, 97, 161, 216, 253, 354.

Martyniaceae

Proboscidea parviflora (Woot.) Woot. & Standl. Doubleclaw, Devil's claw, Unicorn plant. Large gravel wash. Infrequent. EER: 389.

Molluginaceae

Glinus radiatus (Ruiz. & Pav.) Rohrb. Spreading sweetjuice. Dusty dry tank bed. Rare. DHT: 713.

Nyctaginaceae

Allionia incarnata L. Trailing windmills. Large wash, north rocky slope, wet area near tank. Occasional. EER, SPR, DHT, SM: 313, 326, 378, 629, 774.

Boerhavia coccinea Mill. Scarlet spiderling. Large gravel wash. Occasional. EER: 388.

Boerhavia intermedia M. E. Jones. Fivewing spiderling. Wet area near cow tank. Occasional. SPR, SM: 768, 790.

Boerhavia wrightii A. Gray. Largebract spiderling. Rocky slope, large wash, wet area near tank. Occasional. MT, EER, SPR: 267, 316, 773.

Mirabilis sp. L. Four o'clock. Small wash near road, rocky ridgeline. SM, SPR: 98, 324.

Mirabilis bigelovii. Wishbone bush. Large wash. Occasional. SPR, OCW, SM: 219, 396, 570, 811.

Oleaceae

Forestiera shrevei Standl. Desert olive. Large rocky wash, north slope. Rare. SM: 465, 469, 523, 641.

Menodora scabra A. Gray. Rough menodora. North gravel slope, large gravel wash. Occasional. OCW: 102, 169, 751.

Onagraceae

Camissonia brevipes (A. Gray) P. H. Raven. Yellow cups. Large gravel wash. Rare. EER: 856.

Epilobium ciliatum Raf. Fringed willow herb. Greenhouse Study. Rare. SPR: G125.

Orobanchaceae

Orobanche cooperi (A. Gray) A. Heller. Desert broomrape. Gravel roadside. Rare. EER: 846.

Papaveraceae

Argemone gracilentia Greene. Sonoran prickly poppy. Flat open dusty area. Rare. AG: 600.

Eschscholzia californica Cham. California poppy. Large rocky wash, large open gravel wash. Infrequent. SM, EER, OCW: 531, 585, 724.

Eschscholzia glyptosperma Greene. Desert poppy. Large wash. Infrequent. SPR: 683.

Plantaginaceae

Plantago ovata Forssk. Desert Indian wheat. Gravel roadside, large gravel wash, south gravel slope. Frequent. EER, MT, SM, SPR, OCW: 50, 57b, 78b, 197, 554b, 591, 755, G112, G103.

Plantago patagonica Jacq. Woolly plantain. Gravel roadside, dry tank bed, south rocky slope. Frequent. EER, MT, SM, DHT, SPR: 53a, 57a, 78a, 126, 554a, 645, G313, G314, G320, G64.

Poaceae

Achnatherum speciosum (Trin. & Rupr.) Barkworth. Desert needlegrass. Rocky slope. Infrequent. SM: 826.

Aristida adscensionis L. Sixweeks threeawn. Rocky ridgeline, large wash, roadside, north slope. Abundant. SM, SPR, MT: 15, 85, 95, 139, 201, 325, 347, 407, 468, 476, 571, 627, 709, 827.

Aristida purpurea Nutt. var. *purpurea*. Purple threeawn. Rocky ridgeline, large gravel wash, open gravel. Abundant. SPR, MT, SM, OCW: 93, 172, 187, 412, 418, 514, 702, 729, 813.

Aristida purpurea Nutt. var. *longiseta* (Steud.) Vasey. Fendler threeawn. Gravel wash, open gravel. Occasional. MT: 255, 705.

Bothriochloa barbinodis (Lag.) Herter. Cane bluestem. Rocky bank of large wash. Infrequent. MT: 409.

Bouteloua aristidoides (Kunth) Griseb. Needle grama. Large wash, gravel roadside. Infrequent. EER, SPR: 304, 331, 410.

Bouteloua barbata Lag. Sixweeks grama. Large wash, gravel roadside, wet area near tank. Frequent. EER, SPR, MT: 303, 346, 415, 762.

Bouteloua curtipendula (Michx.) Torr. Sideoats grama. Rocky bank of large wash. Frequent. MT, SM: 411, 784, 824.

Bromus arizonicus (Shear) Stebbins. Arizona brome. Greenhouse Study. Rare. SPR: G21.

Bromus rubens L. INTRODUCED. Red brome. Rocky slopes, gravel parking lot, road, dry tank bed, large wash. Frequent. MT, SM, DHT, SPR, EER: 36, 77, 112, 125, 186, 483, 504, 547, 618, 700, G111, G324, G329, G330, G334, G336, G359.

Cynodon dactylon (L.) Pers. INTRODUCED. Bermuda grass. Gravel roadside, large gravel wash. Occasional. SPR, EER: 344, 385.

Dasyochloa pulchella (Kunth) Willd. ex Rydb. Low woolly grass. Gravel roadside, wash, ridgeline. Abundant. SM, MT, OCW: 8, 81, 260, 289, 734.

Digitaria californica (Benth.) Henr. Arizona cottontop. Rocky bank of large wash. Occasional. MT, SM: 408, 792.

Echinochloa crus-galli (L.) P. Beauv. INTRODUCED. Barnyard grass. Roadside, recently flooded. Rare. EER: 287.

Enneapogon desvauxii Desv. ex P. Beauv. Nineawn pappus grass. . Infrequent. SM: 828.

Eragrostis cilianensis (All.) Vign. ex. Janchen. INTRODUCED. Stinkgrass. Roadside, recently flooded, large wash. Occasional. EER, MT: 288, 312, 423.

Leptochloa panicea (Retz.) Ohwi. Mucronate sprangletop. Large wash. Rare. EER: 306.

Leptochloa viscida (Scribn.) Beal. Sticky sprangletop. Disturbed muddy area. Rare. DHT: 366.

Muhlenbergia appressa C. O. Goodding. Devil's canyon muhly. North rocky slope. Infrequent. SM: 617.

Muhlenbergia microsperma (DC.) Trin. Littleseed muhly. Large gravel wash, north rocky slope. Frequent. MT, SM: 3, 111, 421, 527, 625, 703, G42.

Muhlenbergia porteri Scribn. ex Beal. Bush muhly. Large gravel wash, rocky outcrop. Abundant. MT, SM: 110, 429, 445, 503, 801, 843.

Phalaris minor Retz. INTRODUCED. Littleseed canary grass. Large gravel wash. Rare. SPR: 190.

Pleurophis mutica Buckley. Tobosagrass. Flat rocky area. Occasional. SM: 502.

Pleurophis rigida Thurb. Big galleta. Gravel road, large wash, rocky ridgeline. Frequent. SM, MT: 84, 171, 239, 420.

Poa bigelovii Vasey & Scribn. Bigelow's bluegrass. Wash, south rocky slope. Frequent. SM, SPR: 2, 91, 652, G130.

Polypogon monspeliensis (L.) Desf. INTRODUCED. Annual rabbit's foot grass. Dry tank bed, large gravel wash. Occasional. DHT, SPR: 117, 212.

Schismus arabicus Nees. INTRODUCED. Arabian schismus. Large gravel wash. Abundant. SPR, EER: 142, 587, G113, G254.

Schismus barbatus (Loefl. ex L.) Thell. INTRODUCED. Common Mediterranean grass. Rocky ridgeline, tank bed, large wash. Abundant. DHT, SPR, SM: 14, 99, 116, 227, 628, 701, G123, G142.

Tridens muticus (Torr.) Nash. Slim tridens. Roadside, large wash. Occasional. MT, OCW: 292, 733.

Vulpia microstachys (Nutt.) Munro. Small fescue. North rocky slope. Infrequent. SM: 615.

Vulpia octoflora (Walter) Rydb. Sixweeks fescue. Open gravel south slope, large gravel wash. Abundant. SM, SPR: 90, 146, 202, 501, 538, 644, 663, G311, G316, G321, G328, G49, G273.

Polemoniaceae

Eriastrum eremicum (Jeps.) H. Mason. Desert woolly star. Gravel road, ridgeline, south rocky slope, large wash. Occasional. SM, EER, SPR: 79, 551, 577, 650, 691, 852.

Gilia sp. Ruiz. & Pav. *Gilia*. Rocky wash. SM, EER: 497, 854.

Gilia minor A. D. Grant & V. E. Grant. Little *gilia*. South slope, open rocky area, large wash. Infrequent. SM, EER: 557, 594.

Gilia scopulorum M. E. Jones. Rock *gilia*. Large wash. Infrequent. SPR: 688.

Linanthus bigelovii (A. Gray) Greene. Bigelow's *linanthus*. Large wash. Infrequent. SPR: 689.

Polygonaceae

Chorizanthe brevicornu Torr. Brittle spineflower. Gravel road, along ridgeline, large wash. Infrequent. SM, EER: 73, 478, 579.

Chorizanthe rigida (Torr.) Torr. & A. Gray. Devil's spineflower. Large gravel wash. Rare. SPR: 237.

Eriogonum deflexum Torr. Flatcrown buckwheat. Gravel wash, open gravel, disturbed muddy area. Occasional. MT, EER, DHT: 254, 302, 373, 711, G95, G131.

Eriogonum fasciculatum Benth. Eastern Mojave buckwheat. Rocky slopes, gravel parking lot, large gravel wash. Frequent. MT, SPR, OCW: 30, 211, 401a, 749.

Eriogonum inflatum Torr. & Frem. Desert trumpet. Gravel road, along ridgeline, large gravel wash. Frequent. SM, MT, SPR, EER: 71, 290, 335, 715.

Eriogonum trichopes Torr. Little desert trumpet. Large gravel wash. Rare. EER: 384.

Eriogonum wrightii Torr. ex Benth. Bastardsage. Gravel roadside, dry tank bed, large wash. Frequent. MT, DHT, OCW, SM: 37, 118, 401b, 807.

Polygonum argyrocoleon Steud. ex Kunze INTRODUCED. Silversheath knotweed. Low desert hills, wash. Rare. SPR: 4.

Pterostegia drymarioides Fisch. & C. A. Mey. Woodland *pterostegia*. North rocky slope. Rare. SM: 611.

Portulacaceae

Claytonia perfoliata Donn. ex Willd. Miner's lettuce. North facing rocky slope. Rare. SM: 610.

Primulaceae

Androsace occidentalis Pursh. Western rock jasmine. Rocky area, near small wash. Rare. SM: 510.

Pteridaceae

Astrolepis cochisensis (Goodding) Benham & Windham. Cochise scaly cloakfern. Large gravel wash, north rocky slope. Occasional. OCW, SM: 395, 613.

Cheilanthes covillei Maxon. Coville's lipfern. Rocky area, north rocky slope. Occasional. SM: 461, 632.

Cheilanthes parryi (D. C. Eaton) Domin. Parry's lipfern. Rocky area. Occasional. SM: 455.

Notholaena californica D. C. Eaton. California cloakfern. Rocky bank of wash. Occasional. MT: 413.

Pellaea truncata Goodding. Spiny cliffbrake. Gravel slope. Occasional. SM: 441, 447, 464, 791.

Ranunculaceae

Clematis drummondii Torr. & A. Gray. Drummond clematis. Large wash. Occasional. EER, MT, SM: 309, 414, 482, 833.

Rhamnaceae

Condalia globosa I. M. Johnst. Bitter snakewood. Large gravel wash. Occasional. SM: 108, 603, 781.
Ziziphus obtusifolia (Hook. ex Torr. & A. Gray) A. Gray. Lotebush. Gravel roadside, south slope, large wash. Occasional. MT, SM, SPR: 38, 88, 261, 425, 539, 823, 841.

Rubiaceae

Galium aparine L. Stickywilly. Large wash, north rocky slope. Infrequent. SM: 604, 631.
Galium stellatum Kellogg. Starry bedstraw. North rocky slope, large wash. Frequent. SM, OCW: 444, 507, 529, 638, 721, 795.

Salicaceae

Populus fremontii S. Watson. Fremont cottonwood. Disturbed muddy area. Rare. DHT: 371.
Salix gooddingii C. R. Ball. Goodding's willow. Dry tank bed, disturbed. Rare. DHT: 113, 377, 714.

Scrophulariaceae

Castilleja exserta (A. Heller) T. I. Chuang & Heckard. Exserted Indian paintbrush. Large gravel wash. Infrequent. SPR, EER: 149, 578, 675.
Keckiella antirrhinoides (Benth.) Straw. Snapdragon penstemon. Large rocky wash, north rocky slope. Infrequent. SM: 524, 639, 786.
Maurandella antirrhiniflora (Humb. & Bonpl. ex Willd.) Rothm. Roving sailor. Rocky area, north rocky slope. Infrequent. SM: 471, 607.
Penstemon sp. Schmid. Beard tongue. Rocky area. SM: 474.
Penstemon subulatus M. E. Jones. Hackberry beard tongue. Large wash, rocky slope. Occasional. SPR, SM, OCW: 191, 480, 498, 728.
Veronica peregrina L. Neckweed. Greenhouse Study. Rare. SPR: G345.

Selaginellaceae

Selaginella arizonica. Maxon. Arizona spikemoss. Large gravel wash, north rocky slope. Occasional. MT, SM: 135, 451, 460.

Simaroubaceae

Castela emoryi (A. Gray) Moran & Felger. Crucifixion thorn. Roadside. Infrequent. EER, AG: 317, 778.

Simmondsiaceae

Simmondsia chinensis (Link) C. K. Schneid. Jojoba. Large gravel wash. Occasional. OCW: 394, 740.

Solanaceae

Datura discolor Bernh. Desert thorn-apple. Gravel roadside, large wash, disturbed bare soil. Occasional. MT, EER, SPR: 293, 310, 759.
Lycium berlandieri Dunal. Berlandier's wolfberry. Rocky ridgeline, large wash, rocky slope, gravel roadside. Frequent. SPR, MT, OCW: 165, 223, 242, 272, 330, 400, 758.
Lycium cooperi A. Gray. Peach thorn. Wet area near cow tank. Occasional. SPR: 766.
Lycium fremontii A. Gray. Fremont's desert-thorn. Small wash, disturbed muddy area, rocky ridgeline. Frequent. MT, DHT, SM: 70, 376, 559, 830.
Lycium parishii A. Gray. Parish's desert-thorn. Rocky slope. Infrequent. MT: 269.
Nicotiana obtusifolia M. Martens & Galeotti. Desert tobacco. Large wash, gravel roadside, disturbed muddy area. Frequent. SPR, EER, DHT, SM: 158, 168, 218, 280, 308, 342, 369, 812, G152.
Physalis crassifolia Benth. Yellow nightshade ground cherry. East rocky slope, ridgeline. Occasional. MT, SM: 273, 362, 797.
Quincula lobata (Torr.) Raf. Chinese lantern. Roadside, recently flooded. Rare. EER: 281.

Tamaricaceae

Tamarix chinensis Lour. INTRODUCED. Five-stamen tamarisk. Large gravel wash. Rare. SPR: 156, 231.

Typhaceae

Typha domingensis Pers. Southern cattail. Large gravel wash. Rare. SPR: 221.

Ulmaceae

Celtis pallida Torr. Spiny hackberry. Large rocky wash. Rare. SM: 526.

Urticaceae

Parietaria hespera Hinton. Rillita pellitory. Wash, north slope. Frequent. SPR, SM: 194, 609, 667, G5.

Verbenaceae

Aloysia wrightii (A. Gray) A. Heller. Wright's beebrush. Small gravel flat wash, gravel slope. Frequent. SM: 105, 249, 438, 783.

Glandularia gooddingii (Briq.) Solbrig. Southwestern mock vervain. Open gravel. Infrequent. MT: 696.

Viscaceae

Phoradendron californicum Nutt. Mesquite mistletoe. Large gravel wash. Frequent. SPR, OCW, MT: 209, 248, 319, 398, 417, 738.

Zygophyllaceae

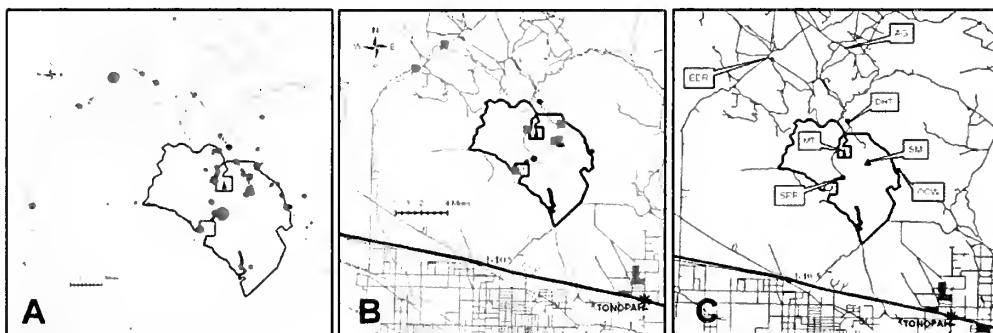
Fagonia californica Benth. [excluded]. Fagonbush. Along old gravel road. Rare. OCW: 735.

Kallstroemia californica (S. Watson) Vail. California caltrop. Gravel roadside, wet area near tank. Infrequent. MT, SPR: 295, 763.

Larrea tridentata (DC.) Coville. Creosote bush. Rocky slope, gravel parking lot, large wash. Abundant. MT, OCW, SPR: 18, 35, 736.



Vascular Flora of Hummingbird Springs. Figure 1. (A) Large wash in Hummbird Springs Wilderness representing Arizona Upland Sonoran Desertscrub with Palo Verde, White Thorn Acacia and Creosote; (B) Large stand of Teddy Bear Cholla (*Cylindropuntia bigelovii*) with the Big Horn Mountains in the background; (C) Seedlings in Greenhouse Study; (D) *Glinus radiatus* in May 2007 at Dead Horse Tank.



Vascular Flora of Hummingbird Springs. Figure 2. (A) Field Collection Points. The size of the circle is relative to the number of collections at that point; (B) Soil Sample Collections Sites for greenhouse study. Minor roads and major streams (Tiger Wash on the left and Jackrabbit Wash on the right) are also shown; (C) General Collection Localities in Hummingbird Springs Wilderness. Abbreviations used: OCW = Old Camp Well, EER = Eagle Eye Road area (where it crosses Tiger Wash and Pump Mine Wash), MT = Microwave tower, SM = Sugarloaf Mountain, SPR = Hummingbird Springs, AG = Aguila Road area.

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APPENDIX A: COMPARISONS BETWEEN FLORAS

Species found in the Kofa National Wildlife Refuge and in the Sierra Estrella Mountains, but not found in Hummingbird Springs Wilderness.

Asclepiadaceae

Asclepias albicans S. Watson

Asteraceae

Brickellia atractylodes A. Gray

Chaenactis carphoclinia A. Gray

Malacothrix sonora W. S. Davis & P. H. Raven

Boraginaceae

Cryptantha decipiens (M. E. Jones) A. Heller

Cactaceae

Peniocereus greggii (Engelm.) Britton & Rose

Euphorbiaceae

Bernardia myricifolia (Scheele) S. Watson

Fabaceae

Astragalus nuttallianus D. C.

Lupinus arizonicus (S. Watson) S. Watson

Grossulariaceae

Ribes quercetorum Greene

Hydrophyllaceae

Phacelia cryptantha Greene

Phacelia rotundifolia Torr. ex. Watson

Lamiaceae

Hedeoma nana (Torr.) Briq

Loasaceae

Mentzelia involucrata S. Watson

Mentzelia affinis Greene

Malvaceae

Hibiscus denudatus Benth.

Horsfordia newberryi (S. Watson) A. Gray

Sphaeralcea coulteri (S. Watson) A. Gray

Sphaeralcea emoryi Torr. ex. A. Gray

Onagraceae

Camissonia boothii (Douglas ex. Lehm.) P. H. Raven

Camissonia californica (Nutt. ex. Torr. & A. Gray) P. H. Raven

Camissonia chamaenerioides (A. Gray) P. H. Raven

Camissonia claviformis (Torr. & Frem.) P. H. Raven

Papaveraceae

Eschscholzia minutiflora S. Watson

Polemoniaceae

Eriastrum diffusum (A. Gray) H. Mason

Gilia flavocincta A. Nelson

Gilia stellata A. Heller

Langloisia setosissima (Torr. & A. Gray ex. Torr.) Greene

Linanthus demissus (A. Gray) Greene

Polygonaceae

Eriogonum thomasi Torr.

Pteridaceae

Astrolepis sinuata (Lag. ex. S. W.) Benham & Windham

Cheilanthes villosa Davenport ex. Mason

Ranunculaceae

Delphinium parishii A. Gray

Resedaceae

Oligomeris linifolia (Vahl) J. F. Macbr.

Scrophulariaceae

Mimulus guttatus D. C.

Solanaceae

Lycium andersonii A. Gray

Sterculiaceae

Ayenia filiformis S. Watson

* indicates this species has been collected in greenhouse from seed bank samples only.

** indicates this species is not likely part of the flora, but is a greenhouse weed.

Species that are in Hummingbird Springs Wilderness, but have not been found in the Kofa National Wildlife Refuge or in the Sierra Estrella Mountains.

Apiaceae

Yabea microcarpa (Hook. & Arn.) Koso-Pol.

Asteraceae

Machaeranthera tagetina Greene

Gutierrezia serotina Greene

Brickellia frutescens A. Gray

Lasthenia californica DC. ex Lindl.

Senecio flaccidus var. *monoensis* (Greene) B. L.

Turner & T. M. Barkley

Brassicaceae

Sisymbrium altissimum L.

Cactaceae

Echinomastus johnsonii (Parry ex Engelm.) E. M.

Baxter

Euphorbiaceae

Chamaesyce micromera (Boiss. Ex Engelm.)

Woot. & Standl.

Fabaceae

Desmodium procumbens (Mill.) Hitchc.

Hoffmannseggia glauca (Ortega) Eifert

Lotus humistratus Greene

Vicia ludoviciana Nutt. ssp. *ludoviciana*

Malvaceae

Gossypium hirsutum L.

Molluginaceae

Glinus radiates (Ruiz & Pav.) Rohrb.

Onagraceae

Epilobium ciliatum Raf.*

Oxalidaceae

Oxalis corniculata L.**

Papaveraceae

Eschscholzia glyptosperma Greene

Poaceae

Muhlenbergia appressa C. O. Goodding

Eragrostis cilianensis (All.) Vign. ex Janchen

Pleuraphis mutica Buckley

Vulpia microstachys (Nutt.) Munro

Polemoniaceae

Gilia minor A. D. Grant & V. E. Grant

Primulaceae

Androsace occidentalis Pursh

Rubiaceae

Galium aparine L.

Simmaroubaceae

Castela emoryi (A. Gray) Moran & Felger

Solanaceae

Lycium cooperi A. Gray

* indicates this species has been collected in greenhouse from seed bank samples only.

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APPENDIX B: Species Collected in the Greenhouse Study

Table listing species collected in the greenhouse study, germinated from soil samples. Months given indicate when the species was in flower or fruit (I = introduced, N = native).

| Family | Species | Month Collected | Number of Collections | Origin |
|------------------------|--|--|-----------------------|--------|
| Amaranthaceae | <i>Amaranthus albus</i> L. | Mar, Apr, May, Jun, Jul, Sept | 10 | I |
| Apiaceae | <i>Daucus pusillus</i> Michx. | Apr, May | 2 | N |
| Asteraceae | <i>Baccharis sarothroides</i> A. Gray | Jan | 1 | N |
| | <i>Filago arizonica</i> * A. Gray | Mar, May, Jun | 5 | N |
| | <i>Filago californica</i> Nutt. | Aug | 2 | N |
| | <i>Laennecia coulteri</i> (A. Gray) G. L. Nesom | Dec | 1 | N |
| | <i>Sonchus oleraceus</i> L. | Jan, Feb, Mar, May, Aug, Sept, Oct, Nov, Dec | 61 | I |
| | <i>Symphyotrichum divaricatum</i> (Nutt.) G. L. Nesom* | Oct | 11 | N |
| Boraginaceae | <i>Amsinckia menziesii</i> (Lehm.) A. Nelson and J. F. Macbr. | Feb, Mar | 6 | N |
| | <i>Cryptantha barbigera</i> (A. Gray) Greene | Mar | 4 | N |
| | <i>Harpagonella palmeri</i> A. Gray | Apr | 1 | N |
| | <i>Pectocarya platycarpa</i> (Munz. & I. M. Johnst.) Munz. & I. M. Johnst. | Mar, Apr | 2 | N |
| | <i>Pectocarya recurvata</i> I. M. Johnst. | Feb, Mar, Apr, May | 12 | N |
| | <i>Plagiobothrys arizonicus</i> (A. Gray) Greene ex. A. Gray | May | 2 | N |
| Brassicaceae | <i>Brassica tournefortii</i> Gouan | Apr, May, Jun | 5 | I |
| | <i>Guillenia lasiophylla</i> (Hook. & Arn.) Greene | May | 5 | N |
| | <i>Lepidium lasiocarpum</i> Nutt. | Jan, Feb, Mar, Apr, Jun | 21 | N |
| | <i>Sisymbrium altissimum</i> L.* | Jun | 1 | I |
| | <i>Sisymbrium irio</i> L. | Apr, Jun | 8 | I |
| Caryophyllaceae | <i>Silene antirrhina</i> L. | May | 1 | N |
| Fabaceae | <i>Lotus humistratus</i> Greene | May | 1 | N |

* indicates this species has been collected in greenhouse from seed bank samples only.

**indicates this species is not likely part of the flora, but is a greenhouse weed.

| Family | Species | Month Collected | Number of Collections | Origin |
|-------------------------|--|--|-----------------------|--------|
| Geraniaceae | <i>Erodium cicutarium</i> (L.) L'Her. ex Aiton | Feb, May, Jun | 9 | I |
| Onagraceae | <i>Epilobium ciliatum</i> * Raf. | Jun | 1 | N |
| Oxalidaceae | <i>Oxalis corniculata</i> L.** | Jan, Feb, Apr, May, Jun, July, Aug, Sept, Oct, Nov | 34 | I |
| Plantaginaceae | <i>Plantago ovata</i> Forssk. | May | 3 | N |
| | <i>Plantago patagonica</i> Jacq. | May, Apr | 11 | N |
| Poaceae | <i>Bromus arizonicus</i> (Shear) Stebbins* | Mar | 1 | N |
| | <i>Bromus rubens</i> L. | Feb, Apr, May, Jun, Jul | 19 | I |
| | <i>Muhlenbergia microsperma</i> (DC.) Trin. | Mar, Apr | 2 | N |
| | <i>Poa bigelovii</i> Vasey & Scribn. | Mar, Apr, May, Jun | 11 | N |
| | <i>Schismus arabicus</i> Nees | Jan, Apr, May, Dec | 16 | I |
| | <i>Schismus barbatus</i> (Loefl. ex L.) Thell. | Feb, Jun, Oct | 5 | I |
| | <i>Vulpia octoflora</i> (Walter) Rydb. | Feb, Mar, Apr, May, Jun | 60 | N |
| | <i>Eriogonum deflexum</i> Torr. | May, Jun | 2 | N |
| Scrophulariaceae | <i>Veronica peregrina</i> L.* | Apr | 2 | N |
| Solanaceae | <i>Nicotiana benthamiana</i> Domin. variety** | Oct | 1 | I |
| | <i>Nicotiana obtusifolia</i> A. Gray | Jul, Aug | 3 | N |
| Urticaceae | <i>Parietaria hespera</i> Hinton | Mar | 3 | N |

* indicates this species has been collected in greenhouse from seed bank samples only.

**indicates this species is not likely part of the flora, but is a greenhouse weed.

ADDITIONS TO THE FLORA OF GRAND CANYON NATIONAL PARK RESULTING FROM NATIONAL VEGETATION MAPPING PROGRAM FIELDWORK

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ABSTRACT

Recent collections from United States Geologic Survey - National Park Service National Vegetation Mapping Program fieldwork in Grand Canyon National Park have documented 25 new records for the park, including 21 new species and four new subspecific taxa. The new records represent 16 families and 24 genera. All 25 taxa are native to the United States; no new non-native taxa were documented. Two taxa, *Perityle intricata* and *Epilobium nevadense*, are new records for Arizona. Additional collections have documented 12 range extensions or rediscoveries of noteworthy taxa.

INTRODUCTION

Grand Canyon National Park (GCNP), of northern Arizona, hosts roughly half of the 3,500 or more vascular plant species found in the state (Stein 2002). Extremes of elevation and topography, a diverse geology, and influences from surrounding biogeographic provinces all contribute to this diversity. An 8,000-foot elevation gradient in the park supports five of the seven major life zones in North America, including the Lower Sonoran, Upper Sonoran, Transition, Canadian, and Hudsonian (Brown 1994). Three of the four major North American Deserts (Sonoran, Mohave, and Great Basin) converge near the Grand Canyon. The park is located within the Colorado Plateau floristic subprovince, but also lies in close proximity to the Mohavian, Great Basin, and Apachian floristic subprovinces (McLaughlin 2007). These rich and varied influences combined with the complex and diverse local environments found in Grand Canyon, appear to make the area a hotspot of plant diversity.

Plant collecting has occurred in GCNP for well over one-hundred years; however a formal floristic inventory of the park has never been funded despite the area's propensity for high plant diversity. Phillips et al. (1987) made a concerted effort to synthesize an up-to-date annotated checklist for GCNP, and various additions to this checklist have been published since that time (Ayers et al. 1995, Brian 2001, Brian et al. 1999). While a current annotated checklist of the flora of GCNP does not yet exist, every year new collections continue to document new species from the park. While not its primary focus, an effort was made to further the goal of compiling a thorough species list for GCNP as part of the United States Geologic Survey - National Park Service (USGS-NPS) National Vegetation Mapping Program (NVMP).

The NVMP is a cooperative effort between the USGS and the NPS Inventory & Monitoring Program. The objective of the program is to classify, describe, and map vegetation communities in more than 270 national park units, including GCNP. Two major final products will result from these ongoing efforts; a digital map of the vegetation communities within each park, and a technical classification and description of these communities. These data, along with a database of plants from each park, will provide NPS natural resource managers with the requisite knowledge of the vegetation needed to make informed management decisions. These data will provide baseline vegetation information for the parks, and will thus be used to guide other scientific inquiries, to provide a gauge for potential climate change, and to direct stewardship efforts of NPS-managed lands.

The NVMP employs the United States National Vegetation Classification, a hierarchical system that organizes natural vegetation based upon coarser-scale physiognomic features, as well as finer-scale floristic distinctions. At the bottom of this hierarchy lies the vegetation *association*, a level which can only be ascertained through an accurate taxonomic inventory of the plant species found within each park. While many common species are readily known by fieldworkers, less common, unusual, or newly adventive species must be collected and identified. Thus, having trained botanists assisting with NVMP efforts has two chief benefits: 1) species are more likely to be accurately identified in the field, or properly collected, identified, and vouchered by herbarium specimens when possible; and, 2) as a by-product of fieldwork and the great distances traversed in the process, trained botanists will better document the floristic diversity within each park (Ahrends et al. 2011). To this end, approximately 1425 herbarium collections were made during NVMP fieldwork in GCNP and Grand Canyon-Parashant National Monument (GCPNM).

METHODS

All collections were made by members of the field crew between March, 2007 and October, 2008 as part of the USGS-NPS NVMP in GCNP and GCPNM. Species identifications were made using standard floras including: the *Intermountain Flora* (Cronquist et al. 1972+), the *Flora of North America* (Flora of North America Editorial Committee 1993+), treatments from the *Manual of Vascular Plants of Arizona* as published in the *Journal of the Arizona-Nevada Academy of Science* and *Canotia* (Vascular Plants of Arizona Editorial Committee 1992+), a *Utah Flora* (Welsh et al. 2003), and *Seed Plants of Northern Arizona* (McDougal 1973). When listed, Colorado River Mile (CRM) references follow Stevens (1983). Nomenclature, nativity, and common names follow the PLANTS database (USDA 2009). All specimens are deposited in the Grand Canyon National Park Herbarium (GRCA); duplicates, when available, are housed in the Deaver Herbarium (ASC) at Northern Arizona University.

The determination of whether a collection was new to Grand Canyon was based upon a review of the published species lists for GCNP (Ayers et al. 1995, Brian 2001, Brian et al. 1999, and Phillips et al. 1987), as well as a thorough query of the ASU, ARIZ, ASC, and GRCA herbaria databases using the Southwest

Environmental Information Network's (2009) on-line query tools (<http://swbiodiversity.org/seinet/index.php>). Digital searches were conducted in three steps: 1) a search of the ASU, ARIZ, ASC, and NAVA databases using a *locality* value of "grand canyon", 2) a complete search of the GRCA database, and 3) a geographic search of the ASU, ARIZ, ASC, NAVA, and GRCA databases for collections made within the boundaries of GCNP. Taxa that were not listed in earlier literature, and were absent from the three-part database search, were deemed to be new records for GCNP. In some instances, for a specimen that seemed to represent a new record, additional research showed that earlier collections existed, or that it had been misidentified.

RESULTS AND DISCUSSION

Approximately 1425 herbarium collections were made during NVMP fieldwork in GCNP and GCPNM during 2007 and 2008. Twenty-five new records for GCNP proper, including two new state records, were documented (see Appendix). These records represent 16 families and 24 genera. All 25 taxa are native to the United States; no new non-native taxa were documented. Additional collections record eight range extensions and four rediscoveries of rarely collected or noteworthy taxa. *Perityle intricata* and *Epilobium nevadense*, both documented from the western Grand Canyon, are new records for Arizona.

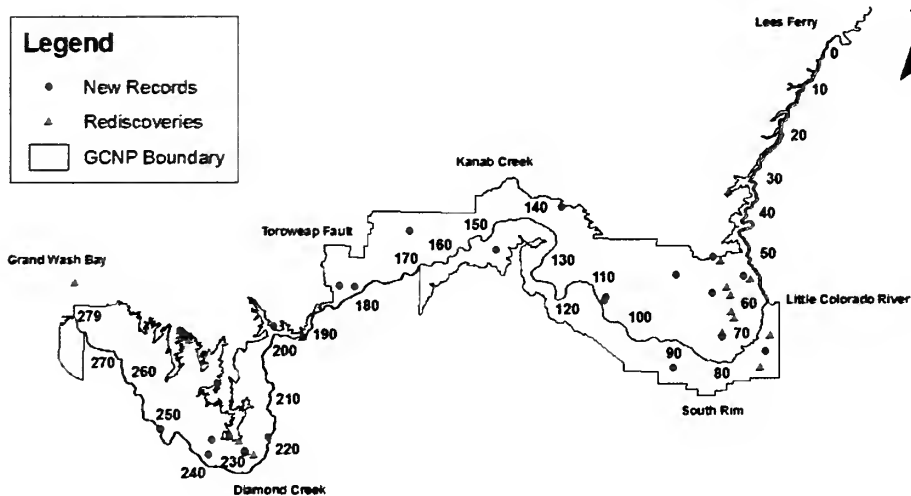
New records were not restricted to a single remote or inaccessible portion of the park, but were made throughout the entire Grand Canyon (fig. 1). Two new records were made from the South Rim, three from the North Rim, and 20 from the Inner Canyon (table 1). Of the Inner Canyon collections, one was from Marble Canyon (CRM 1 - CRM 61), five were from the corridor area (between the Little Colorado River and the Toroweap Fault, CRM 61- CRM 179), and 14 new records were made from the western Grand Canyon (west of the Toroweap Fault at CRM 179). From an east to west perspective, the first new record was documented from near Saddle Mountain, adjacent to Nankoweap Canyon at CRM 52, and the last new record was documented from Surprise Canyon at CRM 248. These collections suggest that the western Grand Canyon likely hosts the majority of potential new records, but that all of GCNP may harbor undocumented plant species.

These collections highlight a number of interesting patterns that attest to the extreme floristic diversity and uniqueness of GCNP. The fact that fairly common species, those which are widespread in both Arizona and in the Southwest, were first documented during this project (e.g., *Rorippa sinuata*, *Linum australe*) speaks to the great immensity and remoteness of the park. Of the 25 new records documented, over 25% commonly inhabit the southwestern United States and have been collected near the Grand Canyon. Based upon distribution data, these species must have undoubtedly been present in the Grand Canyon, but until this project they had not been formally documented within the park boundaries. Roughly one-hundred years of plant collecting in GCNP has not documented all of the area's plant life, and certainly additional species await discovery.

The Grand Canyon, with its myriad habitats and large elevational range, provides refuge for a variety of species growing at the extreme limits of their

distributions. New collections from this project illuminate two interesting biogeographical patterns. Roughly 30% of the new records have affinities to the Great Basin floristic sub-province to the northwest. In general these species barely enter extreme northwestern Arizona, and the western Grand Canyon seems to provide appropriate habitats for these species at the limit of their ranges. Many of the most noteworthy collections from this project, including two new state records, document Great Basin and northern Mohavian species reaching the southeastern extent of their distributions in Grand Canyon (i.e., *Perityle intricata*, *Epilobium nevadense*, *Lupinus flavoculatus*). On the other hand, over 20% of the new records had strong floristic affinities to the Apachian floristic sub-province to the southeast. Species such as *Polygala macradenia* and *Panicum hallii* seem to reach the northwestern limits of their ranges in the Grand Canyon. Less than five percent of the new records had clear affinities to any other adjacent floristic sub-province; however various desert-loving species such as *Senna bauhinoides* and *Carlowrightia arizonica* reach their northern limits in GCNP. These data suggest that the Grand Canyon may act as a southeastern extension of the Great Basin floristic sub-province, a northwestern extension of the Apachian floristic sub-province, and to some extent a northward extension of the Sonoran floristic sub-province (McLaughlin 2007). Collectively, these vouchers attest to how the Grand Canyon provides appropriate habitats for species from disparate floristic regions with various biogeographical affinities.

New records to the flora of Grand Canyon National Park



* Numerals refer to Colorado River Miles downstream from Lees Ferry

Grand Canyon Flora Figure 1. New records to the flora of Grand Canyon National Park.

Table 1. Geographic locations of new records from Grand Canyon National Park.

| Collection # | Scientific Name | GCNP Location |
|------------------------------|---|---|
| KC 1664 | <i>Chrysothamnus viscidiflours</i> ssp. <i>puberulus</i> | Inner Canyon (Corridor) |
| GR 6838 | <i>Cuscuta denticulata</i> | Inner Canyon (Corridor) |
| GR 6832 | <i>Lycium cooperi</i> | Inner Canyon (Corridor) |
| TD 24 | <i>Peteria thompsoniae</i> | Inner Canyon (Corridor) |
| GR 6867, GR 6999, GR 8261 | <i>Hymenopappus filifolius</i> var. <i>cinereus</i> | Inner Canyon (Corridor) / Western Grand Canyon |
| TD 20 | <i>Salvia columbariae</i> | Inner Canyon (Marble Canyon) |
| BR 10875, BR 10876 | <i>Carex utriculata</i> | North Rim |
| KC 1514 | <i>Rorippa sinuata</i> | North Rim |
| GR 7111 | <i>Valeriana arizonica</i> | North Rim |
| KC 1423 | <i>Lotus plebeius</i> | South Rim |
| BR 10843, GR 8101 | <i>Linum australe</i> | South Rim / Western Grand Canyon |
| GR 8245, GR 8364 | <i>Amaranthus torreyi</i> | western Grand Canyon |
| GR 8242 | <i>Asclepias engelmanniana</i> | western Grand Canyon |
| KC 1696 | <i>Carlwrightia arizonica</i> | western Grand Canyon |
| GR 6959, GR 6984 | <i>Chaenactis carphoclinia</i> | western Grand Canyon |
| GR 8110, GR 8232 | <i>Epilobium nevadense</i> | western Grand Canyon |
| GR 8324 | <i>Ericameria nauseosa</i> ssp. <i>consimilis</i> var. <i>mohavensis</i> | western Grand Canyon |
| GR 8145 | <i>Eriogonum pharnaceoides</i> | western Grand Canyon |
| GR 8096 | <i>Eriogonum umbellatum</i> var. <i>juniporinum</i> | western Grand Canyon |
| KC 1655, ST s.n. | <i>Lupinus flavoculatus</i> | western Grand Canyon |
| GR 8327 | <i>Panicum hallii</i> | western Grand Canyon |
| KC 1703 | <i>Perityle intricata</i> | western Grand Canyon |
| GR 6967, GR 8318 | <i>Polygala macradenia</i> | western Grand Canyon |
| GR 6891 | <i>Psathyrotes ramosissima</i> | western Grand Canyon |
| GR 6925 | <i>Senna bauhiniioides</i> | western Grand Canyon |

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APPENDIX

Each species entry includes scientific name, common name, a discussion of geographic range and collection locations within GCNP, and voucher information. The appendix is divided into three subcategories: state records, park records, and range extensions and rediscoveries.

STATE RECORDS

MAGNOLIOPHYTA (FLOWERING PLANTS) - MAGNOLIOPSIDA (DICOTS)

Asteraceae

Perityle intricata (Brandege) Shinnars - Narrowleaf Laphamia. This species is known from Nye, Lincoln, and Clark Counties, Nevada; and also from San Bernardino County, California. A collection from Gneiss Canyon (CRM 236) occurs 100 km east/southeast from nearest known population from north of Las Vegas in the Desert National Wildlife Refuge and documents the species growing at the southeastern limit of its range. (*K. Christie 1703*).

Onagraceae

Epilobium nevadense Munz - Nevada Willowherb. This species is known from the Great Basin of central Nevada to southwestern Utah. It has been documented in neighboring Clark County, Nevada (50 km to the west); and from Washington County, Utah (100 km to the north); collections from Twin Springs Canyon (near CRM 248) document a southeastern extension of the species' range. (*G. Rink 8110, 8232*).

PARK RECORDS

MAGNOLIOPHYTA (FLOWERING PLANTS) - MAGNOLIOPSIDA (DICOTS)

Acanthaceae

Carlowrightia arizonica A. Gray - Arizona Wrightwort. *C. arizonica* was previously documented once in Mohave County from the Artillery Mountains near Alamo Lake, but is more commonly known from the Sonoran Desert of southwestern Arizona. A collection from Gneiss Canyon (CRM 236) is the second voucher from Mohave County, and represents a range extension of 160 km north from the nearest known population. (*K. Christie 1696*).

Amaranthaceae

Amaranthus torreyi (A. Gray) Benth. ex S. Watson - Torrey's Amaranthus. This species is known from California and Arizona; in Arizona it is most common in the central and southern portions of the state. Collections from Twin Springs Canyon (near CRM 248) and the Shivwits Plateau near Kelly Point (near CRM 220) are the northwestern-most records from Arizona. The species has been documented from the Hualapai Mountains (105 km to the south), and from the Paria Plateau (170 km to the east/northeast), but otherwise it had not been documented in northwestern Arizona. (*G. Rink* 8245, 8364).

Asclepiadaceae

Asclepias engelmanniana Woodson - Engelmann's Milkweed. This species is known from the southwestern United States and the Great Plains. In Arizona it is most common in the central and southern portions of the state. A collection from Twin Springs Canyon (near CRM 248) is the northwestern-most collection in Arizona, and documents *A. engelmanniana* at the western limit of its range. It was previously known from the Hualapai Mountains, (105 km to the south) and from the Williams area (150 km) to the southeast. (*G. Rink* 8242).

Asteraceae

Chaenactis carphoclinia A. Gray - Pebble Pincushion. This species is more common to the Sonoran and Mohave Deserts of southern Arizona and California. A collection from Trail Canyon (CRM 219) documents the species growing at the northeastern extent of its range, and documents a range extension of 75 km east from the nearest known population from Grand Wash Bay. (*G. Rink* 6959, 6984).

Chrysothamnus viscidiflorus (Hook.) Nutt. ssp. *puberulus* (D. C. Eaton) H. M. Hall & Clem. - Yellow Rabbitbrush. This subspecies is known from the western United States and regionally is most prevalent in the Great Basin. A collection from the Bill Hall trail near Monument Point is the first to document this taxon within GCNP. (*K. Christie* 1664).

Ericameria nauseosa (Pall. ex Pursh) G. L. Nesom & Baird ssp. *consimilis* (Greene) G. L. Nesom & Baird var. *mohavensis* (Greene) G. L. Nesom & Baird - Rubber Rabbitbrush. This Mohavian variety occurs in California, Nevada, and southwestern Utah. A collection from the Sanup Plateau northwest of Diamond Peak documents the taxon growing at the extreme southeastern limit of its distribution. (*G. Rink* 8324).

Hymenopappus filifolius Hook. var. *cinereus* (Rydb.) I. M. Johnst. - Fineleaf Hymenopappus. This variety is fairly common in the Four Corners region (where Arizona, New Mexico, Colorado and Utah meet); however collections from Mount Akaba, Freya Castle, and the rim of Twin Springs Canyon are the first formal documentation of the taxon from GCNP. (*G. Rink* 6867, 6999, 8261).

Psathyrotes ramosissima (Torr.) A. Gray - Velvet Turtleback. This species occurs in the Mohave Desert of western Arizona and southeastern California. A collection from Boulder Wash (CRM 193) documents the species growing at the northeastern periphery of its range, and occurs 70 km east of the nearest known population from Pearce Ferry. (*G. Rink* 6891).

Brassicaceae

Rorippa sinuata (Nutt.) Hitchc. - Spreading Yellowcress. This species is fairly widespread in North America, and occurs regionally within the Four Corners; however a collection from the Walhalla Plateau on the North Rim is the first record from GCNP. (*K. Christie 1514*).

Cuscutaceae

Cuscuta denticulata Engelm. - Desert Dodder. Scattered collections of this species exist from across the southwestern United States and in Arizona it has mostly been collected in La Paz, and southern Mohave Counties. A collection from Monadnock Amphitheater (CRM 105) is the first from GCNP; it documents an intermediate locality between collections to the south in southern Mohave County, and a collection to the north from near Kanab, Utah. (*G. Rink 6838*).

Fabaceae

Lotus plebeius (Brandege) Barneby - New Mexico Bird's-Foot Trefoil. This species occurs occasionally throughout Arizona. Two collections exist from near Mount Trumbull; and a dubious, older record exists from the Kaibab National Forest, perhaps near the park boundary. A collection from the Palisades of the Desert on the South Rim is the first documented collection from the park. The species may be expected in pinyon-juniper woodlands, rimrock communities, and high elevation grasslands in Grand Canyon. (*K. Christie 1423*).

Lupinus flavoculatus A. Heller - Yelloweyes. This species occurs predominantly in the Mohave Desert and Great Basin of Nevada and California, and uncommonly in southwestern Utah. It was previously collected once in 2001 from near the Wolf Hole Mountains, in northwestern Mohave County. Two collections from Toroweap Valley (CRM 179) represent the second and third records of *L. flavoculatus* in Arizona, and document a 100 km southeast range extension for the species. (*K. Christie 1655, S. Till s.n.*).

Peteria thompsoniae S. Watson - Thompson's Peteria. This species occurs in the California, Nevada, Utah, and sporadically on the Arizona Strip. A collection from Tuckup Canyon (CRM 164) documents the species growing at the southeastern limit of its range. (*T. DeKoker 24*).

Senna bauhinioides (A. Gray) Irwin & Barneby - Twinleaf Senna. This species has Chihuahuan affinities, and is known from Texas, New Mexico, and Arizona. It is commonly collected in southeastern and central Arizona, but is extremely uncommon north of Yavapai County. A collection from Lone Mountain (near CRM 197) is the northwestern-most collection of *S. bauhinioides* in Arizona, and documents a northwestern range extension of 170 km from the nearest known population outside of Cameron (which itself is somewhat of an outlier). (*G. Rink 6925*).

Lamiaceae

Salvia columbariae Benth. - Chia. This species is common to the Sonoran and Mohave Deserts of Arizona at lower elevations. Scattered collections exist from southern Utah, yet the species rarely occurs north of Flagstaff, AZ. A collection from near Nankoweap Butte (CRM 52) documents the species occurring near the northern extent of its range. W. Hodgson, S. Till, and D.

Hill first saw two distinct populations of *S. columbariae* in Kwagunt Canyon in 2007; however the plants were not flowering, and no collections were made. This collection documents their findings. (*T. DeKoker 20*).

Linaceae

Linum australe A. Heller - Southern Flax. This species is seemingly widespread in the southwestern United States and throughout Arizona. One previous record exists from the near Mount Trumbull, yet the species had never been documented from GCNP proper. Collections from the South Rim and the western Grand Canyon near Twin Springs Canyon (CRM 248) document *L. australe* in the park. (*B. Reif 10843, G. Rink 8101*).

Polygalaceae

Polygala macradenia A. Gray - Glandleaf Milkwort. This plant is known from Texas, New Mexico, and Arizona; in Arizona it is more common in the southern portion of the state. Along with several collections from Hualapai lands, collections from Surprise Canyon (CRM 248) and the Sanup Plateau (CRM 220) document *P. macradenia* at the northwestern limit of its range. (*G. Rink 6967, 8318*).

Eriogonum pharnaceoides Torr. - Wirestem Buckwheat. This species is known from New Mexico, Arizona, extreme southwestern Utah, and extreme southeastern Nevada. A few collections exist from near Mount Trumbull, yet the taxon had not been previously documented in the park. A record from Horse Spring Canyon (near CRM 248), in the western Grand Canyon, documents this species growing near the northwestern limit of its distribution. (*G. Rink 8145*).

Eriogonum umbellatum Torr. var. *juniporinum* Reveal - Juniper Buckwheat. This species seems to occur sporadically throughout the Mohave Desert and the Great Basin in isolated desert mountain ranges. A collection from the rim of Twin Springs Canyon documents the taxon growing at southeastern limit of its distribution. (*G. Rink 8096*).

Solanaceae

Lycium cooperi A. Gray - Peach Thorn. This species is known from California, Nevada, southwestern Utah, and northwestern Arizona. A collection from Monadnock Amphitheater (CRM 105) documents the species growing at the eastern extent of its range, and records a 145 km eastern range extension from known populations in Mohave County. (*G. Rink 6832*).

Valerianaceae

Valeriana arizonica A. Gray - Arizona Valerian. This species occurs in the southwestern United States and Texas. It is known from adjacent Forest Service lands near Saddle Mountain, but had not been previously documented within GCNP. A collection from near Saddle Mountain on the North Rim documents the species growing just inside the park boundary. It can be expected to occur uncommonly at higher elevations on the North Rim. (*G. Rink 7111*).

MAGNOLIOPHYTA (FLOWERING PLANTS) - LILIOPSIDA (MONOCOTS)**Cyperaceae**

Carex utriculata Boott - Northwest Territory Sedge. This species is widespread in North America; and in Arizona it occurs most commonly in the White Mountains. A few collections exist from moist, high-elevation meadows on the Kaibab Plateau; however two collections from Hades Lake on the North Rim provide the first documentation of *C. utriculata* within the park. (B. Reif 10875, 10876).

Poaceae

Panicum hallii Vasey - Hall's Panicgrass. This species occurs from Arizona east to Louisiana, and north into Utah. It has been collected in southern and central Arizona, but other than a single collection from Whitmore Canyon, it has never been collected north of Flagstaff. A collection from the Sanup Plateau northwest of Diamond Peak (CRM 220), documents *P. hallii* growing at the northwestern limit of its range. (G. Rink 8327).

RANGE EXTENSIONS AND REDISCOVERIES**PINOPHYTA – GNETOPSIDA (GNETOPHYTES)****Ephedraceae**

Ephedra trifurca Torr. ex S. Watson - Longleaf Jointfir. This species is known from Texas, New Mexico, Arizona, and California. In Arizona it is typically known from the southern portion of the state. A voucher from near Snap Canyon in GCPNM is the second collection from Mohave County, and represents a northwest range extension of 100 km from known populations in Yavapai County. This species has not yet been documented from GCNP proper. (B. Reif 10916).

MAGNOLIOPHYTA - MAGNOLIOPSIDA (DICOTS)**Asteraceae**

Brickellia eupatorioides (L.) Shinnery var. *chlorolepis* (Woot. & Standl.) B. L. Turner - False Boneset. This species occurs from Texas west to Arizona and Utah, and north to Wyoming. It is extremely uncommon in the Grand Canyon, and has only been collected once before from the South Rim. A voucher collection from Twin Springs Canyon seems to be one of the northwestern-most collections in Arizona and documents the taxon growing at the western limit of its range, 40 km west of a known population near Mount Trumbull. (G. Rink 8247).

Brickellia floribunda A. Gray - Chihuahuan Brickellbush. This species occurs in Arizona and New Mexico and has Chihuahuan affinities. It has typically been collected from southeastern Arizona and also from the Verde Valley. The plant is extremely uncommon in the Grand Canyon and has only been collected several times before. A collection from Twin Springs Canyon documents the taxon growing at the northwestern limit of its range. This collection also documents a range extension of 80 km north, from a known population in Hackberry, Mohave County; and 140 km west from a collection from Clear Creek, GCNP. (G. Rink 8208).

Ericameria arizonica R. P. Roberts, Urbatsch, & J. L. Anderson - Arizona Goldenbush. This species was first described in 2005 and seems to be endemic to GCNP. It occurs occasionally on rock faces and in cracks and crevices, in rocky, limestone soils, typically at 2100 meters. The authors of the species suggest that it is of conservation concern. Two vouchers from Twin Springs Canyon document the taxon in the western Grand Canyon, 130 km west of known populations from the South Rim developed area between Hermit Creek and the South Kaibab Trail. (*G. Rink* 8234, 8292).

Brassicaceae

Caulanthus crassicaulis (Torr.) S. Watson - Thickstem Wild Cabbage. This species is known from the Intermountain West and California. A collection from Lava Canyon near Juno Temple is the first from Grand Canyon in over 60 years and documents the species growing at the southeastern extent of its range; 70 km southeast of the closest documented population on the Arizona Strip. The species does not seem to occur south of the Grand Canyon. (*G. Rink* 7026).

Physaria chambersii Rollins - Chambers' Twinpod. This species is mostly known from Utah, Nevada, and California. Along with a single previous collection from Red Canyon, collections from Unkar, Lava, and Nankoweap Canyons record the species growing at the southeastern limit of its range in GCNP, and document a 70 km southeastern range extension from known populations on the Arizona Strip. (*G. Rink* 6790, 7029, 7064).

Lamiaceae

Scutellaria potosina Brandegees var. *kaibabensis* S. Rhodes & T. Ayers var. nov. in press - Mexican Skullcap. Two collections, one from near Saddle Mountain and one from South Canyon, can be attributed to this variety, which is endemic to the eastern edge of the Kaibab Plateau and occurs 160 km northeast of the closest known population of *S. potosina*. *S. potosina* is primarily an Apachian and Chihuahuan species, and these vouchers document the species growing at the northern extent of its range. This taxon has been collected once before from South Canyon, and several times from Forest Service land adjacent to North Canyon. W. Hodgson has documented several populations outside of the park in the vicinity of Saddle Mountain on the Kaibab Plateau. It is uncommon in the park, but likely occurs sporadically in and around Marble Canyon. It should be looked for in that area. (*K. Christie* 1418, *G. Rink* 7091).

Polemoniaceae

Linanthus filiformis (Parry ex A. Gray) J. M. Porter & L. A. Johnson - Yellow Gilia. This species occurs in California, Nevada, Utah, and enters into the northwestern corner of Arizona. It has been collected several times before from GCNP, mostly from the Toroweap Valley and Vulcans Throne. Collections from Boulder Wash (CRM 193) and Kwagunt Creek document *L. filiformis* growing at the southeastern limit of its range. The Kwagunt Creek voucher documents a 60 km range extension to the east from a collection made near Tobar Terrace (CRM 121.5). (*G. Rink* 6749b, 6884).

Phlox amabilis Brand - Arizona Phlox. This species is endemic to Arizona, where it occurs mostly in southern Coconino, Mohave, Navajo, and Yavapai Counties. It is considered to be a Forest Service *sensitive species* and has only been collected once before from GCNP, 100 years ago. A collection from the South Rim near Desert View campground provides important habitat and locality information for this Arizona endemic, and documents the species growing near the northern limit of its range. (*K. Christie 1435*).

Polygonaceae

Eriogonum jonesii S. Watson - Jones' Buckwheat. This Arizona endemic has been collected in scattered locations in the state, mostly between Flagstaff and Winslow. It had been collected once from the Sanup Plateau in GCNP, 30 years ago. Collections from Twin Springs Canyon, the Sanup Plateau northwest of Diamond Peak, the Shivwits Plateau east of Kelly Point, and from Palisades of the Desert near Espejo Point provide valuable habitat and distribution data for the species; documenting it from both the western and eastern reaches of the Grand Canyon. (*B. Reif 10862, G. Rink 8112, 8301, 8329, 8369, 8419*).

Rosaceae

Rubus neomexicanus A. Gray - New Mexico Raspberry. This species is known from southeastern Arizona, as well as from the Four Corners, but has only been collected once from GCNP. A collection from Kwagunt Canyon, southwest of Banta Point, is the first in 70 years. *R. neomexicanus* should be looked for in moist, shaded canyons and similar protected habitats. (*G. Rink 7044*).

Scrophulariaceae

Penstemon ophianthus Pennell - Coiled Anther Penstemon. This species occurs in the southwestern United States and is known from GCNP from a single South Rim collection made in 1965. Another collection from adjacent Forest Service land near Tusayan was made in 1973. A collection from Twin Springs Canyon documents the species occurring at the western extent of its range and seems to be the western-most collection in Arizona, 120 km west of the Tusayan collection. (*G. Rink 8271*).

Erratum

“A survey of the vascular plants in the area of Lime Creek, Maricopa County, Arizona: a unique upland Sonoran Desert environment” by Dawn Goldman and Joni Ward, *Canotia* 6(1): 1–25, 2010. Page 3: The LCSS lies completely within the Sears Club/Chalk Mountain and St. Clair grazing allotments, and not Cartwright grazing allotment as stated. The Cartwright allotment lies further upstream on the Lime Creek.

INDEX TO FAMILIES OF THE VASCULAR PLANTS OF ARIZONA

Bolded treatments are published in volumes 26, 27, 29, 30, 32, 33, and 35 of the *Journal of the Arizona-Nevada Academy of Science* (JANAS) or in subsequent volumes (e.g., 1–5) of *CANOTIA*. Unbolded entries indicate families with no treatments published to date. Figure numbers refer to illustrations in the “Key to Families of Vascular Plants in Arizona” in JANAS 35(2). Selected VPA treatments originally published in JANAS are also available as pdf files online (http://www.canotia.org/vpa_project.html).

- Acanthaceae (Fig. 3)
Aceraceae JANAS 29(1):2. 1995. (L.R. Landrum)
 Adiantaceae (Fig. 1)
Agavaceae Part 1: *Agave* JANAS 32(1):1. 1999. (W. Hodgson)
 Aizoaceae
 Alismataceae
 Amaranthaceae (Fig. 4)
Anacardiaceae CANOTIA 3(2):13. 2007. (J.L. Anderson)
 Apiaceae (Fig. 5)
Apocynaceae JANAS 27(2):164. 1994. (S.P. McLaughlin)
 Araceae
 Araliaceae
Arecaceae JANAS 32(1):22. 1999. (C.T. Mason, Jr.)
 Aristolochiaceae JANAS 32(1):24. 1999. (C.T. Mason, Jr.)
 Asclepiadaceae JANAS 27(2):169. 1994. (E. Sundell)
 Aspleniaceae
 Asteraceae (Figs. 6–7)
Azollaceae CANOTIA 4(2):31. 2008. (G. Yatskievych and M.D. Windham)
Berberidaceae JANAS 26(1):2. 1992. (J.E. LaFerriere; Fig. 9)
 Betulaceae JANAS 33(1):1. 2001. (J.W. Brasher)
 Bignoniaceae JANAS 32(1):26. 1999. (C.T. Mason, Jr.)
 Bixaceae JANAS 27(2):188. 1994. (W. Hodgson)
Blechnaceae CANOTIA 4(2):35. 2008. (G. Yatskievych and M.D. Windham; Fig. 1)
 Boraginaceae (Fig. 9)
 Brassicaceae
Bromeliaceae CANOTIA 3(2):23. 2007. (R. Gutierrez, Jr.)
 Buddlejaceae JANAS 26(1):5. 1992. (E.M. Norman)
 Burseraceae JANAS 32(1):29. 1999. (A. Salywon)
Cactaceae Part One: The Cereoid Cacti JANAS 29(1):6. 1995. (D.J. Pinkava)
Cactaceae Part Two: *Echinocactus* JANAS 29(1):13. 1995. (M. Chamberland)
Cactaceae Part Three: *Cylindropuntia* JANAS 32(1):32. 1999. (D.J. Pinkava)
Cactaceae Part Four: *Grusonia* JANAS 32(1):48. 1999. (D.J. Pinkava)
Cactaceae Part Five: *Pediocactus* and *Sclerocactus* JANAS 33(1):9. 2001. (K.D. Heil and J.M. Porter)
Cactaceae Part Six: *Opuntia* JANAS 35(2):137. 2003. (D.J. Pinkava)
Callitrichaceae JANAS 29(1):15. 1995. (J. Ricketson)
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Cannabaceae JANAS 32(1):53. 1999. (C.T. Mason, Jr.)
 Capparaceae (Fig. 8)
 Caprifoliaceae (Fig. 10)
 Caryophyllaceae (Fig. 10)
Celastraceae JANAS 30(2):57. 1998. (J.W. Brasher)
Ceratophyllaceae JANAS 29(1):17. 1995. (J. Ricketson)
 Chenopodiaceae (Fig. 9)
 Clusiaceae
Commelinaceae JANAS 33(1):19. 2001. (R. Puente and R. Faden)
Convolvulaceae JANAS 30(2):61. 1998. (D.J. Pinkava)
 Cornaceae
Crassulaceae JANAS 27(2):190. 1994. (R. Moran)
Crossosomataceae JANAS 26(1):7. 1992. (C. Mason)
 Cucurbitaceae (Fig. 10)
Cupressaceae JANAS 27(2):195. 1994. (J. Barrett)
 Cuscutaceae
 Cyperaceae (Fig. 18)
Dennstaedtiaceae CANOTIA 4(2):38. 2008. (G. Yatskievych and M.D. Windham; Fig. 1)
Dipsacaceae JANAS 27(2):201. 1994. (J.E. LaFerriere)
 Dryopteridaceae (Fig. 1)
 Elaeagnaceae
 Elatinaceae
 Ephedraceae (Fig. 2)
Ericaceae CANOTIA 4(2):21. 2008. (J.L. Anderson; Fig. 11)
Euphorbiaceae Part One: *Acalypha* and *Cnidoscolus* JANAS 29(1):18. 1995. (G.A. Levin)
Equisetaceae CANOTIA 4(2):41. 2008. (G. Yatskievych and M.D. Windham)
Fabaceae Part One: *Errazuria*, *Marina*, *Parryella*, and *Psoralea* CANOTIA 7:1. 2011 (S. Rhodes, J. Beasley, and T. Ayers; Figs. 12–13)
Fagaceae JANAS 27(2):203. 1994. (L.R. Landrum)
Fouquieriaceae JANAS 32(1):55. 1999. (C.T. Mason, Jr.)
Fumariaceae JANAS 33(1):27. 2001. (S. Holiday and A. Perez)
Garryaceae JANAS 33(1):31. 2001. (R. Puente and T.F. Daniel)
Gentianaceae JANAS 30(2):84. 1998. (C.T. Mason, Jr.)
 Geraniaceae (Fig. 14)
 Grossulariaceae
 Haloragaceae
Hippuridaceae JANAS 29(1):25. 1995. (J. Ricketson)
 Hydrangeaceae
 Hydrocharitaceae
 Hydrophyllaceae (Fig. 14)
Iridaceae Part One: *Sisyrinchium* JANAS 27(2):215. 1994. (A.F. Cholewa and D.M. Henderson)
Iridaceae Part Two: *Iris* and *Nemastylis* JANAS 33(1):35. 2001. (C.T. Mason, Jr.)
Isoëtaceae CANOTIA 5(1):27. 2009. (G. Yatskievych and M.D. Windham)
Juglandaceae JANAS 27(2):219. 1994. (J.E. LaFerriere)
 Juncaceae (Fig. 19)
 Juncaginaceae
 Key to Families of Vascular Plants in Arizona JANAS 35(2):88. 2003. (D.J. Keil)
Krameriaceae JANAS 32(1):57. 1999. (B.B. Simpson and A. Salywon)
Lamiaceae Part One: *Agastache*, *Hyptis*, *Lamium*, *Leonurus*, *Marrubium*, *Monarda*, *Monardella*, *Nepeta*, *Salazaria*, *Stachys*, *Teucrium*, and *Trichostema* JANAS 35(2):151. 2003. (C.M. Christy, D.Z. Damrel, A. Henry, A. Trauth-Nare, R. Puente-Martinez, and G. Walters)
Lemnaceae JANAS 26(1):10. 1992. (E. Landolt)
Lennoaceae JANAS 27(2):220. 1994. (G. Yatskievych)
 Lentibulariaceae
 Liliaceae (Fig. 19)
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Loasaceae JANAS 30(2):96. 1998. (C.M. Christy)
 Lythraceae
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Malvaceae Part One: All genera except *Sphaeralcea*. JANAS 27(2):222. 1994. (P.A. Fryxell)
Marsileaceae CANOTIA 5(1):30. 2009. (G. Yatskievych and M.D. Windham)
Martyniaceae CANOTIA 3(2):26. 2007. (R. Gutierrez, Jr.)



- Meliaceae
- Menispermaceae** JANAS 27(2):237. 1994. (J.E. LaFerriere)
- Menyanthaceae** JANAS 33(1):38. 2001. (C.T. Mason, Jr.)
- Monotropaceae** JANAS 26(1):15. 1992. (E. Haber)
- Molluginaceae** JANAS 30(2):112. 1998. (C.M. Christy)
- Moraceae
- Najadaceae
- Nyctaginaceae (Fig. 14)
- Nymphaeaceae** JANAS 29(1):26. 1995. (J. Ricketson)
- Oleaceae (Fig. 15)
- Onagraceae (Fig. 15)
- Ophioglossaceae
- Orchidaceae
- Orobanchaceae
- Oxalidaceae** JANAS 30(2):115. 1998. (R. Ornduff and M. Denton)
- Papaveraceae** JANAS 30(2):120. 1998. (G.B. Ownbey with contributions by J.W. Brasher and C. Clark)
- Passifloraceae** JANAS 33(1):41. 2001. (J.M. MacDougal)
- Phytolaccaceae** JANAS 33(1):46. 2001. (V. Steinmann)
- Pinaceae
- Plantaginaceae** JANAS 32(1):62. 1999. (K.D. Huisinga and T.J. Ayers)
- Platanaceae** JANAS 27(2):238. 1994. (J.E. LaFerriere)
- Plumbaginaceae
- Poaceae (Fig. 20)
- Polemoniaceae** CANOTIA 1:1. 2005. (D. Wilken and M. Porter)
- Polygalaceae
- Polygonaceae (Fig. 15)
- Polypodiaceae** CANOTIA 5(1):34. 2009. (G. Yatskievych and M.D. Windham; Fig. 1)
- Pontederiaceae** JANAS 30(2):133. 1998. (C.N. Horn)
- Portulacaceae** CANOTIA 2(1):1. 2006. (A. Bair, M. Howe, D. Roth, R. Taylor, T. Ayers, and R.W. Kiger)
- Potamogetonaceae
- Primulaceae** JANAS 26(1):17. 1992. (A.F. Cholewa; Fig. 16)
- Psilotaceae** CANOTIA 3(2):32. 2007. (R. Gutierrez, Jr.)
- Pyrolaceae** JANAS 26(1):22. 1992. (E. Haber)
- Rafflesiaceae** JANAS 27(2):239. 1994. (G. Yatskievych)
- Ranunculaceae (Fig. 15)
- Resedaceae
- Rhamnaceae** CANOTIA 2(1):23. 2006. (K. Christie, M. Currie, L. Smith Davis, M-E. Hill, S. Neal, and T. Ayers)
- Rosaceae Part One: *Rubus***. JANAS 33(1):50. 2001. (J.W. Brasher)
- Rubiaceae** JANAS 29(1):29. 1995. (L. Dempster and E.T. Terrell; Fig. 16)
- Ruppiaceae
- Rutaceae
- Salicaceae Part One: *Populus***. JANAS 26(1):29. 1992. (J.E. Eckenwalder)
- Salicaceae Part Two: *Salix***. JANAS 29(1):39. 1995. (G.W. Argus)
- Salviniaceae** CANOTIA 4(2):50. 2008. (G. Yatskievych and M.D. Windham)
- Santalaceae** JANAS 27(2):240. 1994. (J.E. LaFerriere)
- Sapindaceae** JANAS 32(1):76. 1999. (A. Salywon)
- Sapotaceae** JANAS 26(1):34. 1992. (L.R. Landrum)
- Saururaceae** JANAS 32(1):83. 1999. (C.T. Mason, Jr.)
- Saxifragaceae** JANAS 26(1):36. 1992. (P. Elvander; Fig. 16)
- Scrophulariaceae (Fig. 17)
- Selaginellaceae** CANOTIA 5(1):39. 2009. (G. Yatskievych and M.D. Windham)
- Simaroubaceae** JANAS 32(1):85. 1999. (J.W. Brasher)
- Simmondsiaceae** JANAS 29(1):63. 1995. (J. Rebman)
- Solanaceae Part One: *Datura***. JANAS 33(1):58. 2001. (R. Bye)
- Solanaceae Part Two: Key to the Genera and *Solanum***. CANOTIA 5(1):1. 2009. (S.T. Bates, F. Farruggia, E. Gilbert R. Gutierrez, D. Jenke, E. Makings, E. Manton, D. Newton, and L.R. Landrum)
- Solanaceae Part Three: *Lycium***. CANOTIA 5(1):17. 2009. (F. Chiang and L.R. Landrum)
- Sparganiaceae** JANAS 33(1):65. 2001. (J. Ricketson)
- Sterculiaceae
- Tamaricaceae
- Thelypteridaceae** CANOTIA 5(1):49. 2009. (G. Yatskievych and M.D. Windham)
- Tiliaceae
- Typhaceae** JANAS 33(1):69. 2001. (J. Ricketson)
- Ulmaceae** JANAS 35(2):170. 2003. (J.W. Brasher)
- Urticaceae** JANAS 26(1):42. 1992. (D. Boufford)
- Valerianaceae
- Verbenaceae
- Violaceae**. JANAS 33(1):73. 2001. (R.J. Little; Fig. 17)
- Viscaceae** JANAS 27(2):241. 1994. (F.G. Hawksworth and D. Wiens)
- Vitaceae
- Zannichelliaceae
- Zygophyllaceae (Fig. 17)